COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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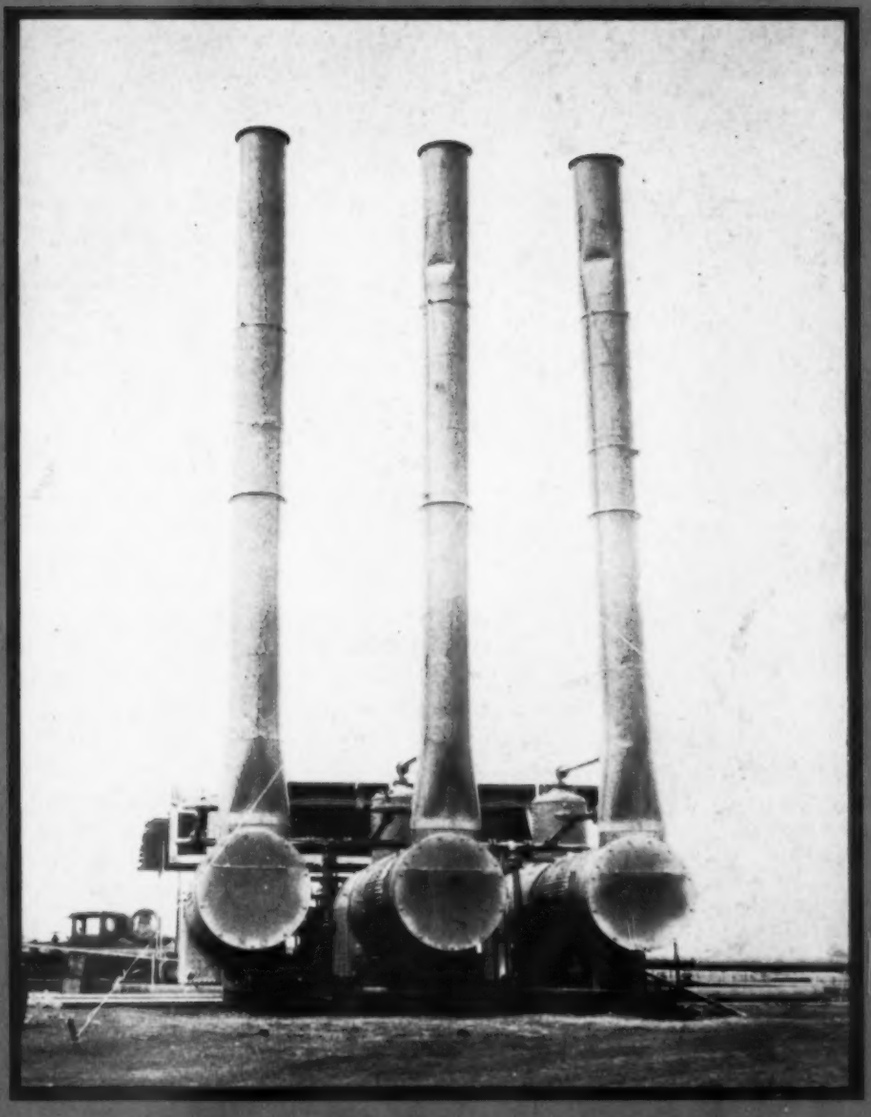

Outside boiler plants are a familiar sight in the oil fields. Despite advances in boiler practice, units of this type are doing their part in the war effort.

Adjustable-Blade Axial-Flow Pumps for Circulating Water ▶

Heating System for Naval Warehouse Employs Minimum Critical Materials ▶

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A-716

C-E installations span the whole gamut of steam generating requirements from small stoker-fired boilers of less than 50 horsepower to the largest power station units. C-E

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200 MADISON AVENUE, NEW YORK, N. Y.

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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EDITORIAL

Colloidal Fuel Again Under Investigation

With a view toward conserving fuel oil as burned under power boilers, and with particular reference to those plants in which conversion to coal is difficult without extensive and costly alterations, the U. S. Bureau of Mines has for the past year been engaged in making further studies of the burning of colloidal fuel—a mixture of oil and pulverized coal. These studies have led to an arrangement with the Atlantic Refining Company for conducting extensive tests with colloidal fuel at that company's Point Breeze Refinery. Various mixtures and their adaptability to different types and sizes of furnaces will be investigated.

Early patents on burning coal-oil mixtures date back more than sixty years and it will be recalled that during World War I inconclusive tests were carried out on colloidal fuel by L. W. Bates under the auspices of the Submarine Defense Association. Subsequent investigations were conducted over a period of years in England, which included trials under boilers, first on the liner *Scythia* and later on the *Berengaria*. That these were not entirely successful may be inferred from the fact that the work was not carried further; also, at that time the economic advantage was questionable. One of the chief difficulties was to find a suitable fixateur that would render the mixture stable for an extended period.

In furnaces that have been designed to burn either pulverized coal or oil, as is the case with many large modern steam generating units, conversion presents no problem and there is no reason for employing colloidal fuel; but with those that have been designed to burn only oil, the chances are that the furnace heat release per cubic foot will be too high for pulverized coal without incurring troublesome slagging, unless output is materially reduced. While the coal-oil mixture would tend to lessen this difficulty, it would still present a major problem, especially with mixtures containing as much as sixty per cent coal. Hence, it is imperative that a very low-ash coal be employed and that it be ground extremely fine; also, the fusion temperature of the ash is important.

A comprehensive review of what had been accomplished to date with coal-oil mixtures was contained in a paper before the Joint A.S.M.E.-A.I.M.E. Fuels Meeting at St. Louis last fall by W. C. Schroeder, of the Bureau of Mines, under whose direction the present studies are being made.

It is significant that, although previous investigations centered around marine applications, those now under way are directed toward stationary boilers. This is primarily due to the limited fuel oil now available for use by industrial plants, whereas the urgency of marine transportation does not permit of experimental applications in boiler furnaces of restricted proportions which would likely present the greatest problems.

Despite the lack of definite progress in this direction over the last twenty-five years, in which economic considerations may have been a factor, the impelling needs of the present emergency are likely to bring about more conclusive results.

A Dangerous Bill

A bill is now pending before the Senate which would create an Office of Scientific and Technical Mobilization. Among its purposes would be: to effectuate maximum utilization of our scientific and technical resources, facilities and personnel; to promote, coordinate and develop scientific and technical projects, methods and training; to promote the establishment of standard specifications and designs; to acquire patents and patent rights and authorize their use on a non-exclusive basis; to advise the President and Congress on scientific and technical matters; and in time of war to requisition patents and technical facilities vital to the war effort.

The office would be headed by an administrator appointed by the President and a Board whose membership would consist of one representative each of labor, industry, agriculture and the public, and two additional members who would be scientists or technicians.

It is pointed out by its sponsor, Senator Kilgore, that there has been no plan or preparation for the difficult period or technological transition from war to peace; that national welfare will depend on science's ability to meet these problems of transition; and that the need for government leadership and machinery through which science can serve the nation will be greater then than it is now.

One of the things that has made this nation industrially preeminent has been the contribution of science and technological development under our system of free initiative, which has proved a major factor in our present war effort. In the transition period from war to peacetime economy, this must be preserved unhampered by domination of bureaucracy such as would most certainly result through enactment of the proposed legislation.

While government regimentation is accepted as necessary to the successful prosecution of total war, it is fraught with danger in times of peace, and most dangerous of all would be its extension to the field of technological development. Moreover, it would add one more body to an already top-heavy bureaucracy that will resist liquidation with the signing of peace.

The bill should not be permitted to become enacted because of indifference on the part of technical men who have much at stake in keeping the field unencumbered.

Adjustable-Blade Axial-Flow Pumps for Circulating Water

These are the first pumps of this type to be used for condenser circulating service and are installed at the Venice Steam Stations of the Union Electric Company of Illinois. The physical and economic considerations leading to their selection are discussed; they are fully described; and both model tests and field performance are given.

By **L. N. REEVE**, Hyd. Engr.
Stone & Webster Engineering Corp.
and **J. D. SCOVILLE**, Asst. Ch. Engr.
S. Morgan Smith Co.

A NEW type of pump has been used and has justified its adoption both mechanically and economically in meeting the rather unusual condensing water requirements of the Venice Steam Stations of the Union Electric Company of Illinois. These plants are located at Venice, Illinois, on the east bank of the Mississippi River, directly opposite the City of St. Louis.

During the latter part of 1939, the Union Electric Company of Illinois authorized Stone & Webster Engineering Corporation to design and supervise the construction of its proposed 400,000-kw ultimate capacity steam plant at Venice, now known as Venice Station No. 2. At this site is an older steam station with three units having an aggregate rated capacity of 62,500 kw, which is now known as Venice Station No. 1.

It is not unusual that jobs of this magnitude bring to light new and interesting problems and, in the case of the Venice job, one such problem was to supply circulating water for the condensers in both the old and new steam stations, involving a total of about 500,000 gpm for the proposed ultimate development. The large water supply was secondary in importance to the wide range of pumping head and capacity which the new pumping equipment had to meet due to the difference in size of units; size, length, and arrangement of distribution lines; valve controls; and wide range of river levels at the intake. The complex arrangement of the circulating water mains and valve controls is indicated in Fig. 1 (plan) and Fig. 2 (longitudinal section through caisson and power station). It should be noted that the supply and discharge lines for both stations are interconnected. This is necessary since the circulating water pumps for the old station were removed and it was desired, for economical reasons, to utilize the old pressure and discharge mains which pass under the levee from the river caisson to No. 1 Plant as a part of the new water-distribution system.

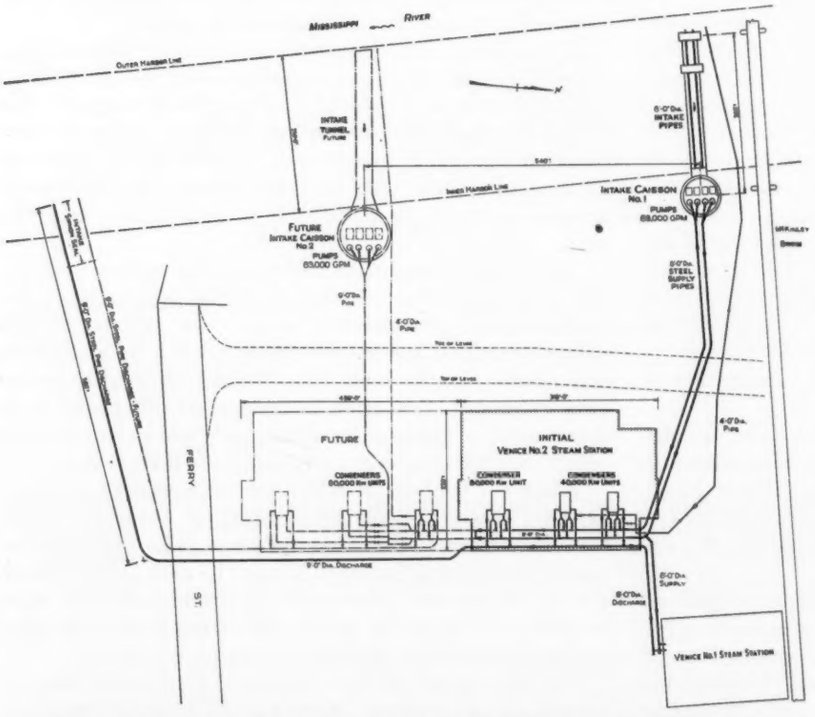

Fig. 1—Arrangement of circulating-water mains and valve controls

The circulating water requirements of the old steam station at Venice had previously been supplied by three centrifugal pumps located in a concrete caisson or intake well at the inner harbor line on the bank of the river. This caisson, which is of heavy concrete construction, 63 ft outside diameter and about 100 ft overall in height, was constructed in 1925 for the Venice No. 1 Station. The three pumps installed in the caisson were rated to deliver a total of about 130,000 gpm under a maximum head of 31 ft, but under the maximum pumping head on the completion of Venice No. 2, namely, about 46 ft, they would supply only about one-half their rated capacity, or say, 65,000 gpm. Inasmuch as the water requirements for both stations on the completion of the initial installation of two 40,000-kw units and one 80,000-kw unit in the new station were estimated at 249,000

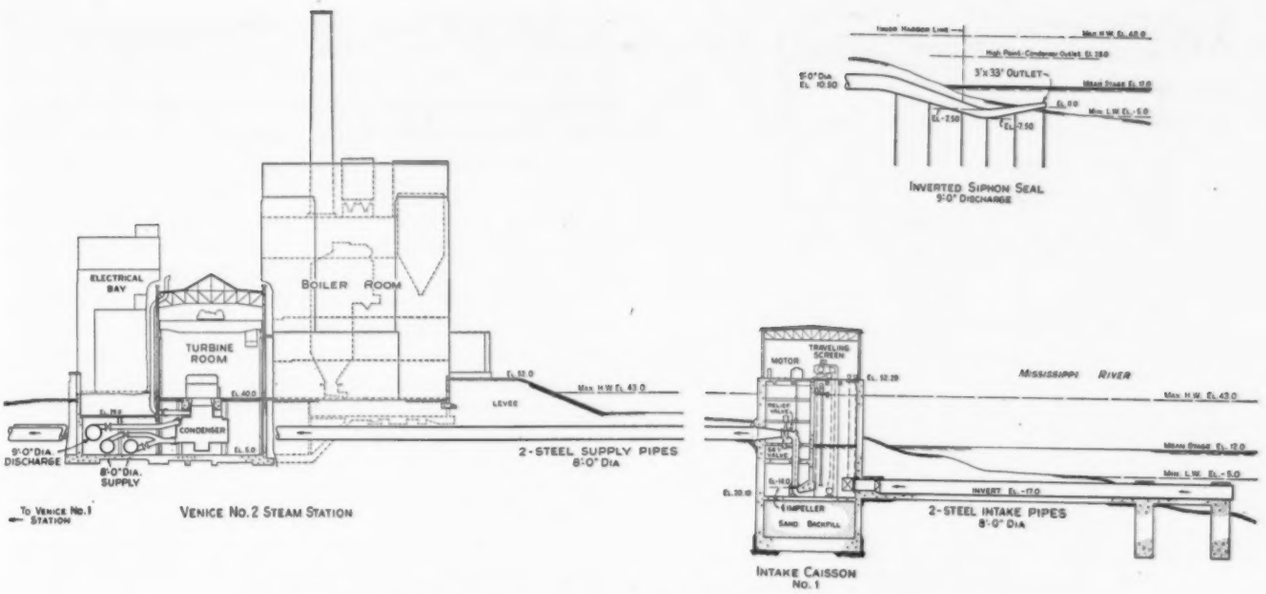

Fig. 2—Longitudinal section through intake caisson and power station

gpm, it was obvious that new pumps of much larger capacity and pumping head and also of a type requiring minimum space must be selected if the old caisson were to serve as the intake for the new conditions.

Three pumps, each having a capacity of 83,000 gpm under 46-ft pumping head, would just meet the circulating water requirement for the 62,500 kw in Venice No. 1 and 160,000 kw in No. 2, but an extra or spare pump of the same capacity was deemed essential to avoid having 80,000-kw steam capacity out of service whenever a pump should be shut down for repairs or due to screen or gate trouble. In selecting this particular size of pump, consideration was given to the prevailing size of the larger units to be installed in the new station, the size of the river caissons required to house the pumping equipment, the overall water supply requirements of 498,000 gpm and cost of the equipment and its operation. It was decided to install four of the new pumps in the existing caisson and at a later date to construct a caisson of about the same size arranged to house four additional pumps of the same size which are required for the ultimate development. Fig. 1 shows the location of the present and proposed future caisson.

To construct a new river caisson would have involved an expense of about $1,000,000 and therefore the major problem was to investigate the feasibility of installing the four pumps, of 83,000 gpm each for the initial development, within the restricted space available in the existing river caisson. It was equally important to select pumping equipment that would be best suited to operate efficiently under a very wide range of operating head and capacity to meet the new conditions. The quantity of water required varies with the load on the station and with the temperature of water in the river. Under some conditions the pumping head does not exceed 15 ft, whereas under future conditions the maximum pumping head will be about 46 ft.

To meet these difficult conditions the adjustable blade axial-flow pump manufactured by the S. Morgan Smith Company was found to have very definite advantages over the fixed-blade or mixed-flow types. There is a material saving when either head or quantity is less than the maximum because flattening of the impeller blade angle is equivalent to reducing the size of the pump, and thus capacity and head are adjusted without throttling and without speed reduction, yet maintaining high efficiency over the whole range of operation. Resulting power saving is of material importance in view of the enormous quantity of water handled. The positive mechanical control of the impeller blade angle provides the equivalent of an almost unlimited number of fixed-blade pumps within the capacity and head ranges. The pumps selected can operate under the wide head range from 0 to 50 ft and also deliver from 0 to 112,000 gpm, which is 135 per cent of their rated capacity.

An hydraulically operated butterfly valve of the Dow type at the discharge end of each pump is equipped with auxiliaries which close the valve automatically within 15 sec in case of power failure.

General Pump Operating Conditions

Two pumps have been running since December 1941 and two additional ones have recently been installed and placed in commercial operation. These pumps are required to operate under a wide variation of conditions. The suction level can vary from a possible minimum of −7 to a maximum of +43. The impeller elevation is −14. The pumping head will vary from about 15 to 46 ft, depending on how many pumps are in operation and the number of condensers in service.

The conditions governing the supply of water to the two plants, as described previously, made it extremely difficult to predict the range of operating conditions. The water always contains silt and sand, and at times the amount by volume reaches 15 to 20 per cent. Under flood conditions as much as 10 ft of sand has settled on the river side of the screens. Also, there is considerable trash in the water at flood stage, which is removed by traveling screens and trash racks, thus protecting the pumps. Fig. 3 shows a section through the intake caisson and pump house. Ice formations are also a source of trouble during cold weather. Experience with the previous

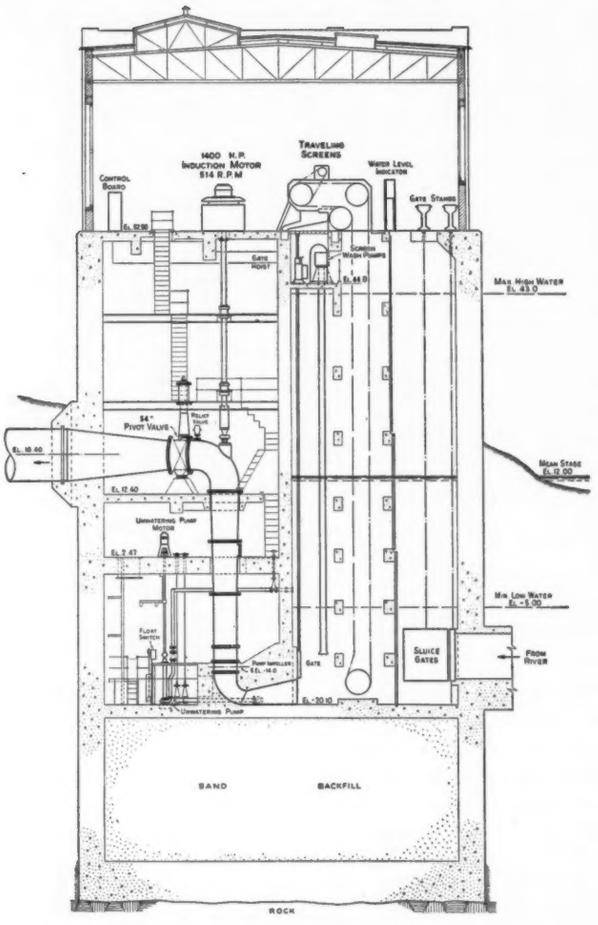

Fig. 3—Section through intake caisson No. 1 and pump house

pumps demonstrated the desirability of providing reverse flow through the new pumps for flushing out the sand and debris which is deposited in the pump well and in the suction conduit. Fig. 4 shows a plan sectional view through the caisson.

All of these considerations influenced the selection of the type of pumps used and led to the adoption of the adjustable-blade type units. The flexibility of this type of pump has met the varying conditions at Venice.

Advantages of Adjustable Blade Type of Pump

Among the advantages of the adjustable-blade type of pump making it suitable for circulating water supply condensers are:

1. Flexibility.
2. Flat efficiency characteristics over a wide range of discharge under varying head.
3. Excess capacity providing extra discharge for emergencies.
4. Low shutoff head.
5. Low starting torque.
6. Relatively low reverse speed.

Design Characteristics

The pumps were guaranteed for a discharge of 41,000 to 83,000 gpm each under heads varying from 30 to 45 ft, and are driven at 514 rpm by 1400-hp induction motors of the squirrel-cage type, operating three phase, sixty cycles at 2300 volts. These motors are larger than required for normal conditions but the size selected permits advantage to be taken of the excess capacity of the pumps when the requirements are abnormal.

Description of Pumps

Fig. 6 is a vertical section through the pump showing in detail the more important features, while Fig. 7 is a shop assembly of the first two pumps. The suction tube, as shown in Fig. 6, is of the elbow type which permits uniform acceleration of the water to the impeller and insures even distribution of velocity across the area. This produces favorable flow within the impeller, thereby improving efficiency and reducing cavitation. Vibration from hydraulic sources is reduced to a minimum by the use of this tube. Fig. 8 is a photograph of the steel-plate liners of the suction tubes. This type of intake requires a minimum of space and depth for admission of water.

The impeller which is 46-in. diameter has four controllable-pitch blades shaped to eliminate cavitation for the conditions under which the pumps must operate. The moving parts within the hub are lubricated by immersion in heavy oil maintained through the hollow shaft from a rotating cup above the pump casing.

Blade Adjustment

The blade pitch can be altered while the pump is in operation. This is accomplished by axial movement of a crosshead in the hub which is connected to each blade by a link and lever. This crosshead is moved up or down by a rod extending through the hollow shaft. A nut on the upper end of the rod transmits the force to accomplish this motion. The nut is turned by the slow speed end of a heliocentric gear. The high-speed end of this gear is rotated by a small a-c, three-phase motor. The whole mechanism is actuated through a magnetic reversing switch controlled by a pair of self-synchronous control motors. The transmitter is mounted in the split-shaft housing just above the pump casing, which also contains

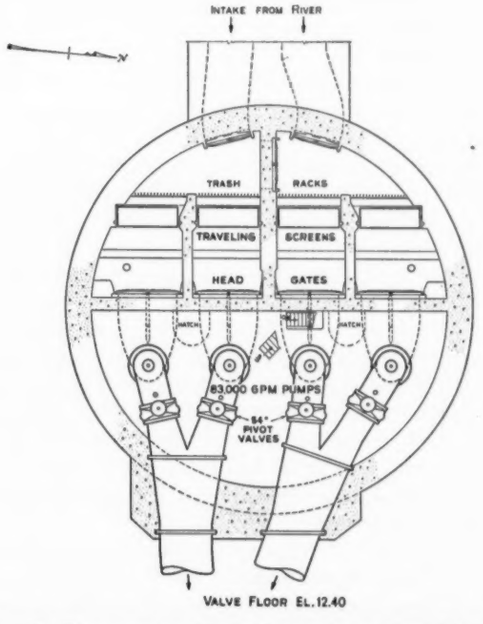

Fig. 4—Plan section through intake caisson No. 1

the three-phase blade adjusting motor, with the heliocentric gear, nut and screw. Fig. 9 shows the assembled mechanism.

The receiver motor is mounted on the control panel for the pump in the steam station. By means of a control knob and indicating dial at the switchboard, the contactor is closed, causing the blade-adjusting motor to travel the blades open or closed as required. Connection between these control motors is made through proper leads and rotating slip rings mounted on the split-shaft housing. About 60 sec are required to traverse a complete pitch change from minimum to maximum angle.

As shown in Fig. 6, there is a steel shaft alley around the shaft. As the pump was originally designed, grease-lubricated bearings were used and no protective casing installed. Due to the large amount of sand in the water it was found impossible to exclude sand from the bearings with consequent wear on the shaft, even though the attempt was made to maintain excess grease pressure by using special sealing devices on each end of the bearings. It was finally found necessary to use water-lubricated bearings and to install the shaft alley. Clear water under excess pressure is passed through each bearing and the ingress of sand prevented by a specially designed

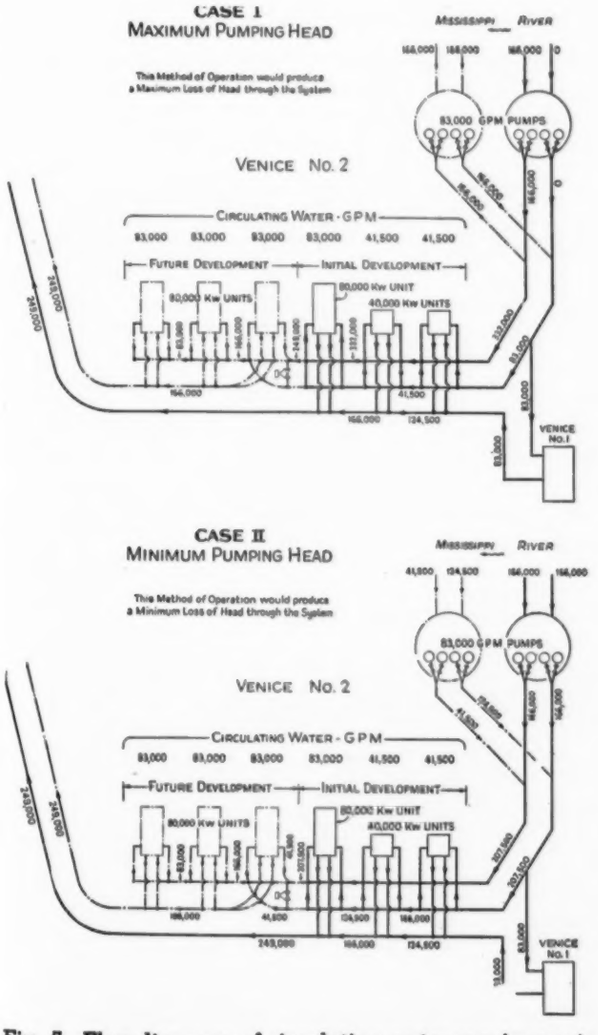

Fig. 5—Flow diagrams of circulating-water requirements —ultimate development

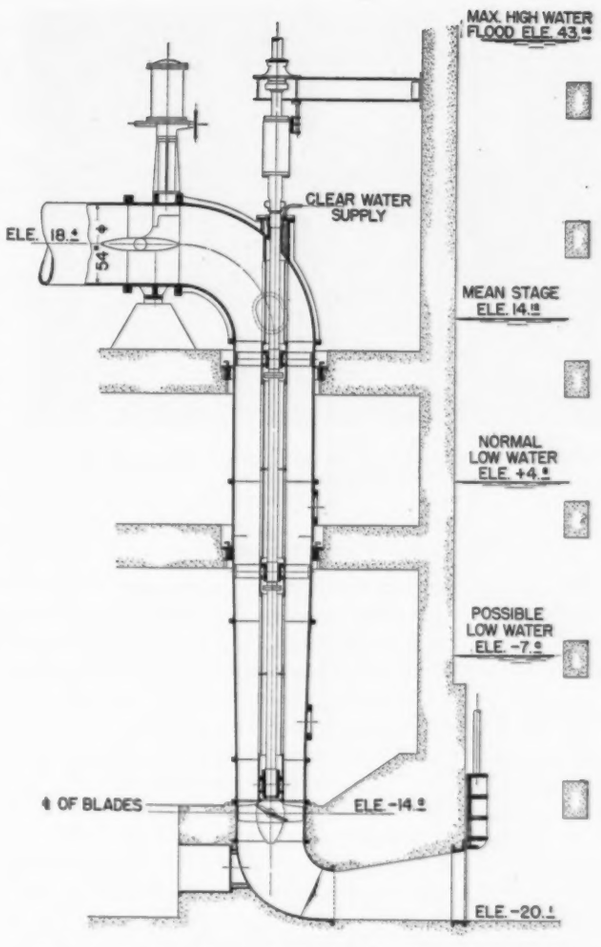

Fig. 6—Section through Venice No. 2 condenser pump

sealing device at the bottom of the casing. This has proved satisfactory. The bearings above the pump elbow are of babbitt and oil-lubricated.

The impeller blades and hub are of cast steel. The shaft is a forging with replaceable stainless steel sleeves fastened to it at each bearing, and the suction elbow tube is of plate steel. Cast iron is employed for the impeller barrel, the diffuser section, pump column and discharge elbow.

Model Tests

The Engineers specified that model tests be made to demonstrate the suitability and operating characteristics of these pumps for this particular installation. No similar pumps had ever been built for this service and the high specific speed and relatively high head of this installation justified such tests. Fig. 10 is a cross-section through the model pump. The impeller diameter was 10 in. and tests were made under field operating head ranges; that is, from 15 to 45 ft. The total dynamic head was measured by piezometers located in the suction tube 3 in. from the outer end, and in the discharge tube 3 ft downstream from the outlet elbow. The efficiencies obtained, therefore, charged the pump with the losses on both elbows. Discharge was measured with a standard weir which has been rated by volumetric measurement and the power input was obtained with an electric dynamometer.

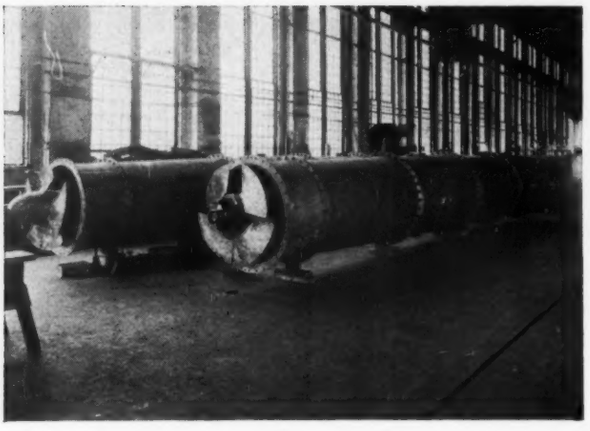

Fig. 7—Shop view of condenser pumps showing adjustable blade impellers

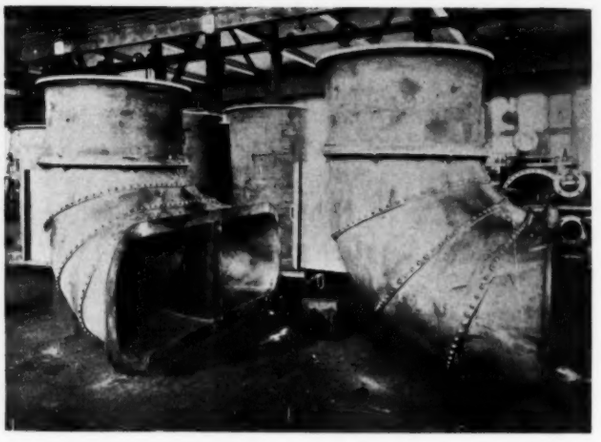

Fig. 8—Shop view of plate steel elbow suction tubes for Venice No. 2 pumps

Cavitation Characteristics

It is to be noted that the model tests were made at prototype head but with less impeller submergence than occurs in the actual installation. Other tests had previously been made on this particular design of impeller to determine its cavitation characteristics. Possibly it would be well to interject here that cavitation is the "boiling" of water due to low pressure caused by relatively high suction head and high relative velocity between the blades and the water. Pitting is the removal of metal from the impeller as the result of cavitation.

Cavitation phenomenon is clearly illustrated by the photographs in Fig. 11 and the curve in Fig. 12. The photographs were taken from the suction side of the model impeller through a glass window in the suction tube. At this time the pump was in operation and the corresponding prototype discharge was 137,000 gpm with a head of 25 ft. Point *A* on the curve (Fig. 12) is pump efficiency with a suction head of 12 ft at the center line of the impeller. Photograph *A* (Fig. 11) is a flash picture of the flow conditions on the suction side of the impeller. These pictures were taken with a Speedotron lamp with a flash duration of about one ten-thousandth of a second and therefore show instantaneous flow pattern within the pump. At the other end of this series is photograph *D* taken when there was a suction lift of 8 ft on the impeller with a resultant drop in efficiency on the pump as indicated by point *D* on the curve (Fig. 12). It can be clearly seen that general cavitation occurred on the blades at point *D*. Some cavitation is shown in photograph *C* and also there was some drop in efficiency. The bright spots on the rounded part of the impeller hub are reflected light, not cavitation. These photographs show clearly the correlation between cavitation and efficiency. It is this drop in efficiency which is used in cavitation tests to determine the safe suction head for a given pump discharge and head.

Similar tests were made on the model pump for other heads and quantities so that determination could be made as to where to set the impeller with reference to the suction level. It was decided that with the center of the impeller at −14, no serious cavitation would occur with a head of 45 ft and suction water level of −7. Actually, after almost a year's operation, slight pitting was found near the entrance edge of the impeller close to the periphery both on the top and bottom of the blades. Further observation of the model impeller with a stroboscope through windows in the pump barrel showed that the shape of the leading edge was partly responsible for this. Slight changes in the shape of the blades were made, and a small triangular piece cut from the leading edge of each blade and replaced with stainless steel, to eliminate pitting under the operating conditions.

Field Performance

Two of these pump units have been in operation for more than a year and except for the initial trouble due to excess sand, have proved highly satisfactory. Fig. 13

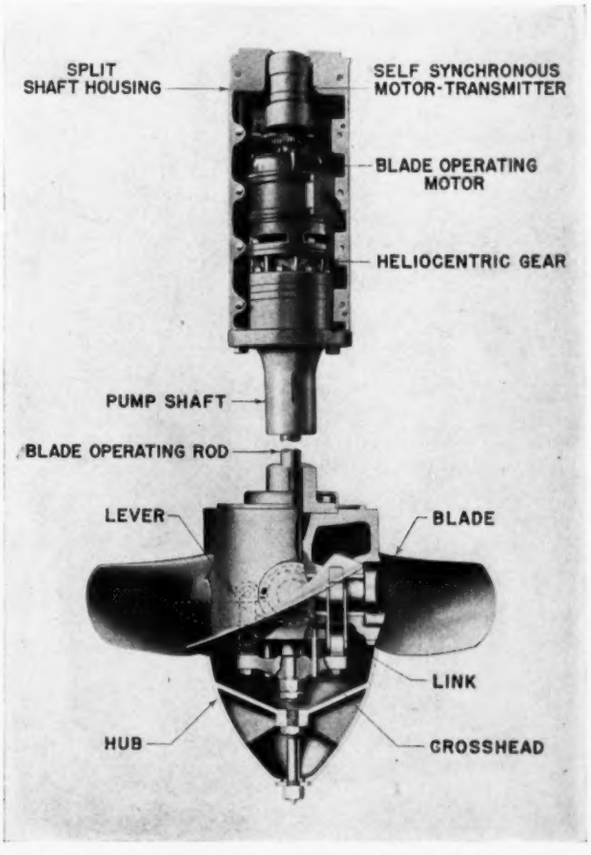

Fig. 9—Section through impeller hub and split sleeve in shaft showing operating mechanism

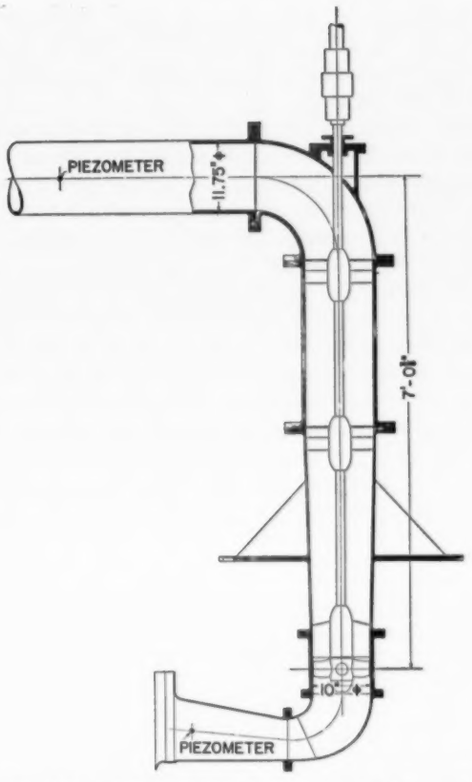

Fig. 10—Section through 10-in. model pump

shows the expected performance of the pump based on the model tests previously referred to, in which the efficiency has been adjusted for size, according to the Moody Formula. This formula for the efficiency, E, of the full size pump is:

$$\text{Prototype Efficiency } E = 1.00 - (1 - e) \times \left(\frac{d}{D}\right)^{1/4}$$

where e = model efficiency at peak point
d = model impeller size (10-in. diam)
D = Prototype impeller size (46-in. diam)

There have been some cases where the expected differential between model test efficiency and field test efficiency on large pumps has not been realized. This was apparently due to the fact that the model impellers were highly polished. For the Venice project the model impeller was given a commercial finish on the blades. Investigation has demonstrated that for pumps where both the model and the prototype impellers were given comparable finish on the surfaces the Moody differential has proved reliable.

Each of the several curves of Fig. 13 shows the performance at a constant horsepower input at varying head and discharge. The blade angle or pitch is varied to obtain the results shown. The head-quantity curves for one pump discharging through one condenser and through two condensers are shown intersecting the head-discharge curves. These curves are based on field tests

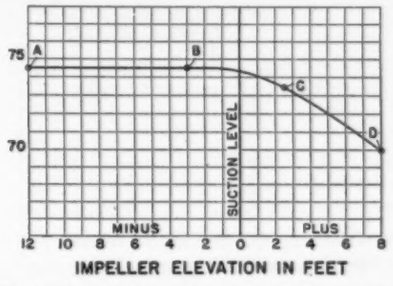

Fig. 12—Effect of variation of suction lift or suction head on model efficiency. Prototype discharge 137,000 gpm, head 25 ft

at Venice in which the head and kilowatt input to the motor were measured. No water measurement was made, so the data are based on the computed quantity from the measured pump horsepower and head and expected efficiency. Fig. 14 shows how closely the field data check with those stepped up from the model tests at several blade positions.

Flexibility, Flat Efficiency Characteristics, and Excess Capacity

At the beginning of this article mention was made of several advantages of the adjustable blade pump which could be elaborated. Fig. 5 shows the original flow diagrams prepared by the Engineers to show two cases of maximum flow conditions which might prevail on the completion of the ultimate development of Venice when all generating units are at full load.

Case 1 shows flow condition with all four pumps in one river intake delivering their rated capacity of 83,000 gpm each, and two pumps in the other intake delivering 83,000 gpm each. Under these pumping conditions all the condensers in both Venice stations would receive the

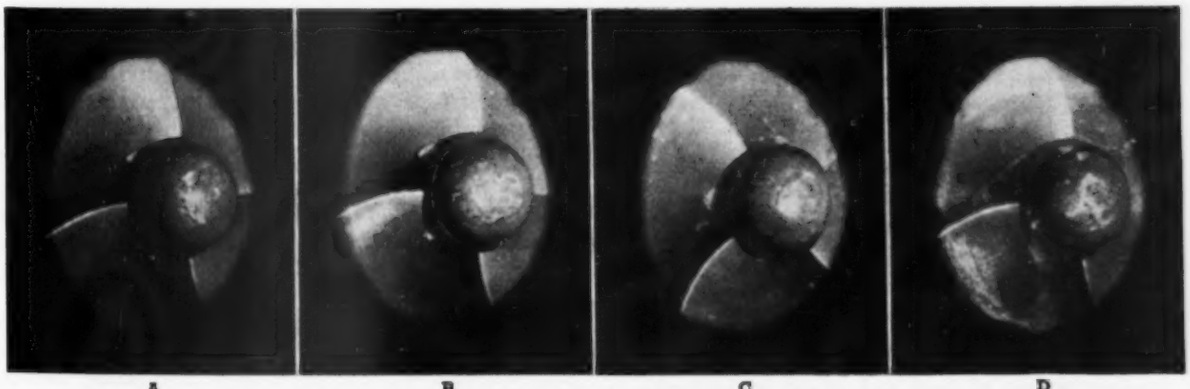

Fig. 11—Instantaneous photographs of cavitation on model pump impeller

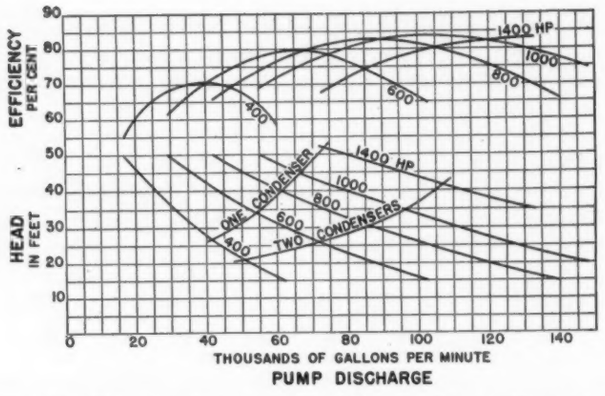

Fig. 13—Characteristic curves of Venice No. 2 adjustable-blade pumps. 83,000 gpm, 514 rpm, 46 ft head

water supply required for the full rated kilowatt output of the various steam units. This particular set of conditions is that which would result in the maximum pumping head requirement, namely, 46 ft, and assumes that the river level would be at its lowest stage, namely, −5. The following tabulation shows in summary form the losses which go to make up the 46-ft pumping head.

SUMMARY OF MAXIMUM PUMPING HEAD REQUIREMENTS

Ultimate Development—See Case 1, Fig. 5

(*a*)	Intake tubes to pump suction	3.0 ft
(*b*)	Supply mains—pump to condensers	13.2 "
(*c*)	Condensers (initial units)	16.0 "*
(*d*)	Discharge lines—condensers to river	7.0 "
(*e*)	Water level differential (river level gr. −5.0 and *C* discharge outlet at gr. 1.8)	6.8 "
	Total maximum pumping head	46.0 ft

* Loss for future units assumed not over 16 ft.

It should be noted from the above that 6.8 ft of the maximum pumping head is required because of the water level differential which exists during extreme low river level, this being due to the fact that the outlet ends of the discharge mains are at a higher level than the low stage of the river. This provision was necessary since otherwise the siphonic lift would exceed safe limits to insure siphonic action; see Fig. 2.

Case 2 shows the eight pumps in both caissons being operated so that the total circulating water requirements would be so distributed throughout the distribution lines as to result in a minimum pumping head. Assuming that the pumps should be operated in this manner, the maximum flow in either one of the 8-ft supply lines would be only 207,500 gpm, as compared with 332,000 gpm under *Case 1*. It should be obvious that for such a

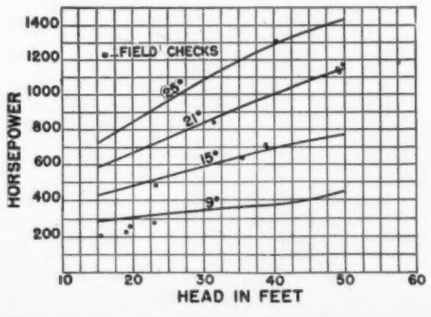

Fig. 14—Comparison of field and model performance of adjustable-blade pump. 83,000 gpm, 514 rpm, 46-ft head

wide difference in flow through the distribution lines there would be a much wider differential in total head loss, since losses through the mains vary about as the square of the velocity.

These diagrams are only two of the possible examples of the unlimited flow conditions which may actually exist when operating the pumps in the two river intakes to meet the varying demands for circulating water, not only during the initial development, but as conditions change with the ultimate development.

In this connection, attention is called to Fig. 1, which shows intake No. 2 located about 540 ft downstream from the existing caisson, and it will be noted that only one 9-ft, diameter supply line is now proposed. It is evident that the flow and pumping head conditions throughout the distribution system are widely different from the assumed conditions at the time the work was started. This change for the future intake was made possible without making any change in the pumping

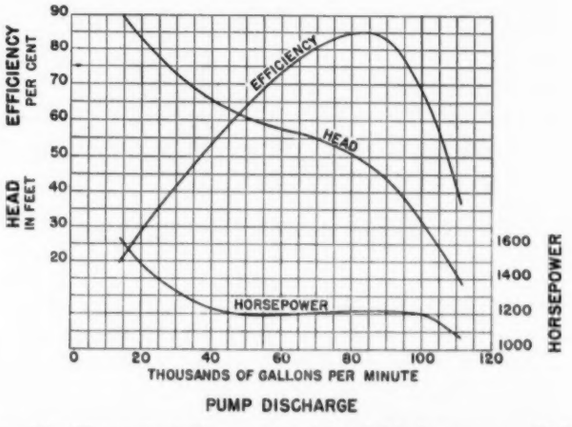

Fig. 15—Characteristic curves of fixed-blade pump. 83,000 gpm, 514 rpm, 46-ft head

equipment, since the flow and pumping head for the new arrangement falls within the range of the adjustable-blade axial-flow pumps first purchased for the original layout.

This is a concrete example of the suitability of the new type of pump to meet changed conditions which may occur as plans develop for steam plant installations. The pumping equipment is usually purchased before complete and final plans are made for a steam plant. Also, additions to an initial development may vary somewhat from the engineer's assumptions.

Fig. 13 shows the head variation with discharge, with one and two condensers in operation. As pointed out, due to the complexity of the piping and locations and varying size of condensers in the two stations, many other combinations can occur which will require wide variation of discharge for any given head within the operating range. The adjustable-blade pump can take care of this to better advantage than any other type. To illustrate this, curves in Fig. 15 are plotted giving the performance of a fixed-blade pump running at 514 rpm designed for best efficiency at 83,000 gpm at about the same head as the adjustable type. In the tabulation below is a comparison of the two types of pumps based on requirements at Venice with one pump supplying either one or two condensers.

COMPARISON OF TWO TYPES OF PUMPS

Gpm	Adjustable-Blade Hd	Adjustable-Blade Hp	Fixed-Blade Hd	Fixed-Blade Hp	
73,500	52.0	1400	54.0	1210	
66,500	44.8	1000	56.0	1205	One pump
61,500	40.0	800	57.2	1200	One condenser
54,000	34.0	600	59.5	1190	
41,500	27.0	400	65.0	1225	
112,000*	41.5	1400	59.0	2380	
96,000	34.5	1000	38.0	1210	
86,000	30.5	800	47.0	1220	
72,000	26.0	600	54.5	1210	One pump
50,500	21.0	400	60.5	1190	Two condensers

* Two fixed-blade pumps required at this discharge.

This tabulation illustrates the fundamental difference between the fixed- and adjustable-blade pumps. When less flow is required for a condenser, at low load on the steam turbine, the head is reduced. The adjustable-pitch pump accommodates itself to this condition by a reduction in pitch and in horsepower. To reduce the discharge of a fixed-blade pump, its valve must be throttled which raises the head on the pump itself although less is required. There is little, if any, saving in horsepower. There is, therefore, no advantage in throttling the fixed-blade pump. It is true that at one point, 73,500 gpm, less power is required to drive the fixed-blade unit, but at all other combinations the adjustable-blade design effects a large saving in energy. The adjustable-blade pump can handle 112,000 gpm through two condensers at 41.5-ft head whereas the fixed-blade design cannot produce this head and discharge. Two of the fixed-blade pumps would be required with a horsepower input of 2380. This illustrates the excess capacity potentialities of the adjustable-blade type and its flexibility, which is not available in the fixed-blade type.

Low Shutoff Head

On the Venice installation an hydraulically operated Dow valve is installed at the discharge of each pump. Therefore, these pumps must be capable of starting against closed valves. If a fixed-blade pump were used, a shutoff head of 100 to 120 ft would be produced. The power input to the pump would be about twice the motor capacity. This difficulty is overcome in the adjustable-pitch type by starting with the blades in a flat position. Fig. 16 shows the pump shutoff head and the horsepower at various blade angles. At the minimum position the shutoff head is only 28 ft and the horsepower about 200. This curve illustrates how rapidly the shutoff head increases with increasing blade pitch. With the blades flat, the adjustable pump can be put on the line, the valve opened and then the blades opened to discharge the required amount of water. With this starting procedure the shock to the circulating-water system is a minimum.

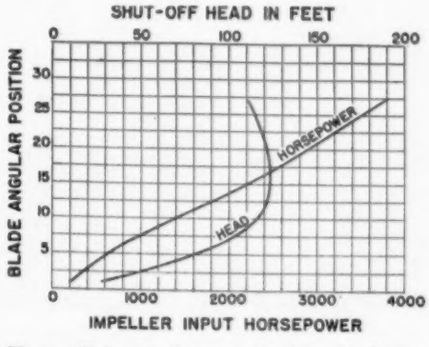

Fig. 16—Shut-off head characteristics of adjustable-blade pump at various blade positions

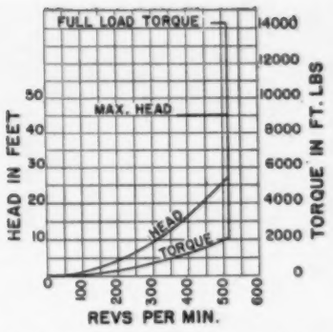

Fig. 17—Head and torque of adjustable-blade pump during starting cycle

Low Starting Torque

Another advantage of starting as described above is the low starting torque for the adjustable-blade pump. Fig. 17 illustrates this. It will be seen that the full-load motor torque is 14,300 ft-lb whereas the required pump torque at synchronous speed is only 2000 ft-lb or 14 per cent of that at full load. This characteristic makes it possible to use a standard synchronous motor with a saving in cost and an increase in efficiency.

Relatively Low Reverse Speed

Provision has been made to reverse the flow through the pumps at Venice to wash out the deposited sand. If the blades on the pump rotating backward are opened wide, the maximum speed will be 830 rpm. With the blades at largest pitch position a maximum flushing effect will be obtained with a minimum speed of rotor, since in the intermediate pitch position, the overspeed is higher. If a fixed-blade pump were used, the reverse speed would be 1030 rpm under 45-ft head and the discharge less, since the blade pitch would be at a lesser angle for normal fixed-blade design.

Conclusion

Close cooperation between the operating engineers of the Union Electric Company, the designing engineers of Stone & Webster and the S. Morgan Smith Company, has resulted in working out this new and far-reaching application of the controllable pitch idea so universally accepted in modern hydraulic turbine practice. The major problem developed, due to extreme sand content in the water, was overcome through three-way conferences. The experience of the Union Electric Company during years of steam plant operation along the Mississippi River has thus been combined with the construction and manufacturing experience of the Stone & Webster and S. Morgan Smith organizations. This has resulted in a definite contribution to the more efficient handling of condenser water in steam power plants, including control of flow directly from the boiler room switchboard.

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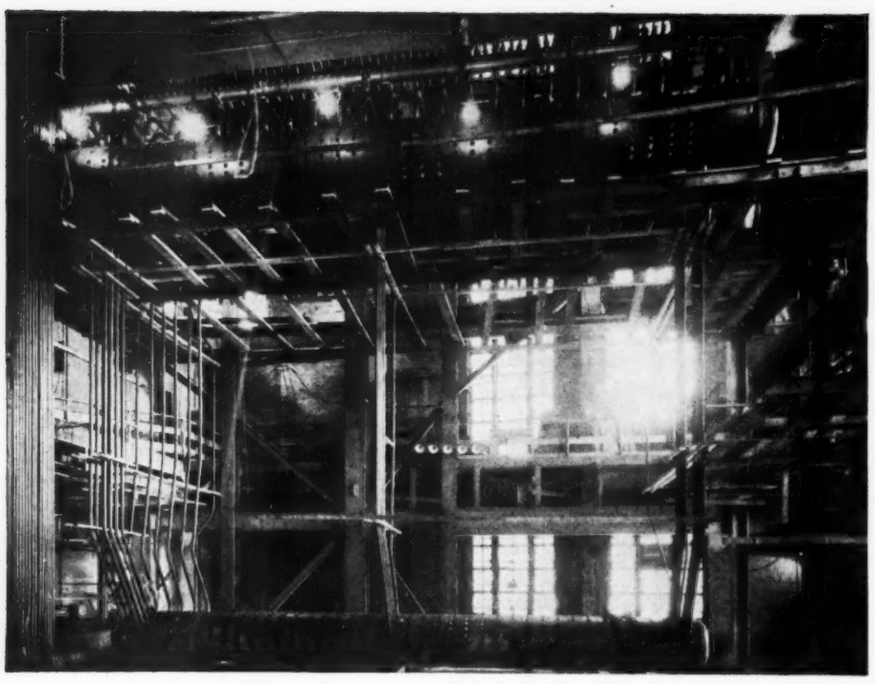
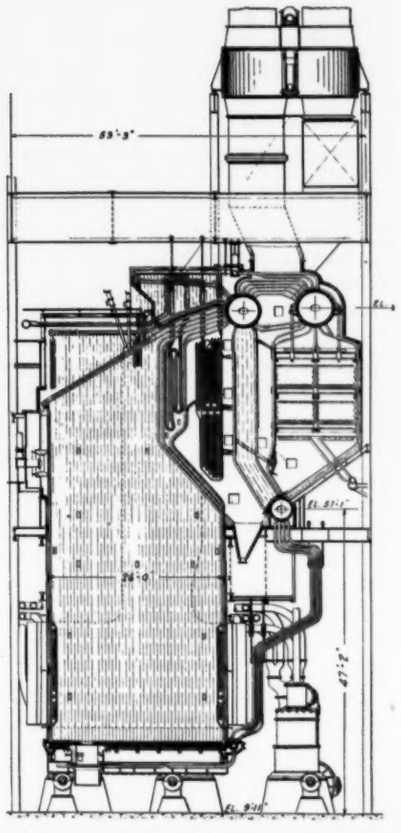
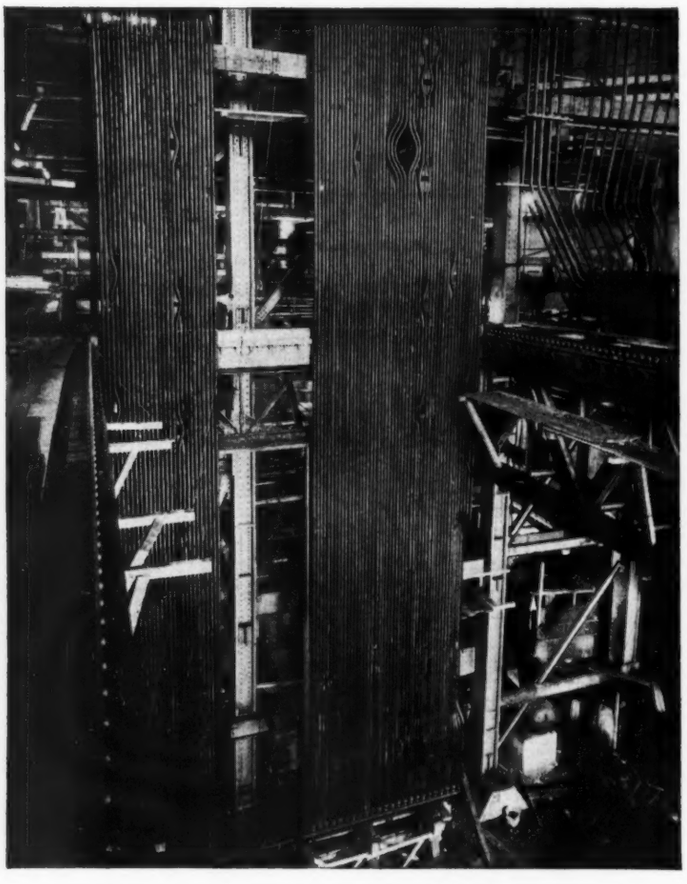


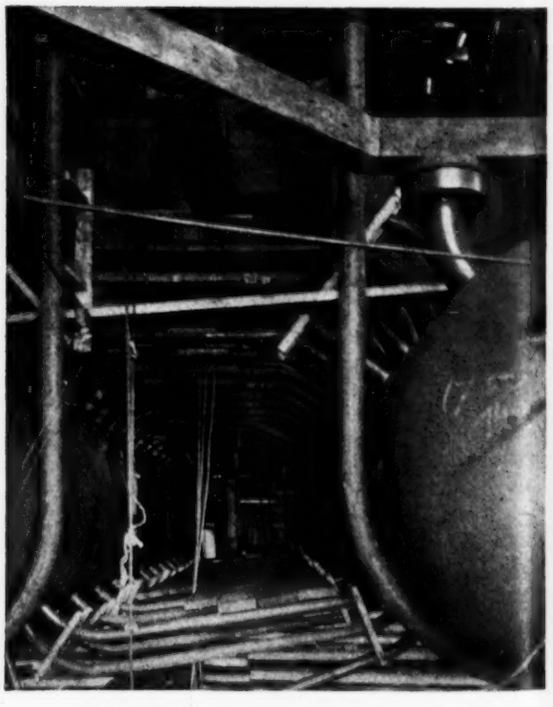
Construction view showing assembly of boiler drums and initial installation of boiler tubes from upper front drum and rear drum to mud drum



Cross-section through boiler and furnace



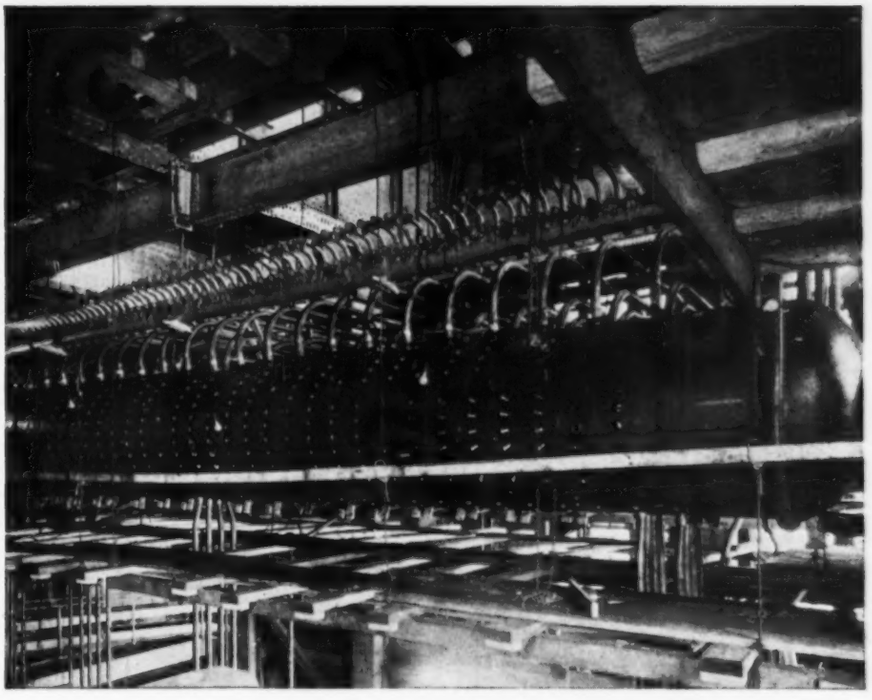
Installation of bifurcated waterwall tubes secured to the lower header of left-hand wall of furnace



Upper front and rear drums showing cross-over steam and cross-under water circulating tubes

High-Pressure Boiler Unit for a Large Eastern Utility

THESE pictures show construction views of a recently completed C-E steam generating unit which has the distinction of being the highest pressure unit designed to produce a million pounds of steam per hour at maximum continuous rating. The operating pressure will be 1625 lb with a total steam temperature of 955 F at the turbine throttle. The unit is pulverized-coal corner fired, using four tangential burners (three nozzles each) and with four auxiliary horizontal burners to be used for superheat control. The superheater is of the two-stage, controlled bypass, interbank type supplying high-pressure steam superimposed on existing 200-lb equipment. The continuous-slagging furnace has a volume of 54,400 cu ft gross. All furnace waterwalls are composed of 3-in. diameter plain bifurcated tubes. The equipment also includes a continuous fin-tube split-type economizer, two regenerative air heaters with a total of 142,600 sq ft of surface and three 32,700-lb (actual) bowl-mill type pulverizers.



View of 54-in. upper front drum showing cross-over steam circulating tubes secured to drum; also superheater inlet header with nipples

View showing boiler tubes connecting upper 54-in front drum and lower 36-in mud drum

View inside furnace showing one corner opening for tangential burners and openings in front wall for auxiliary burners

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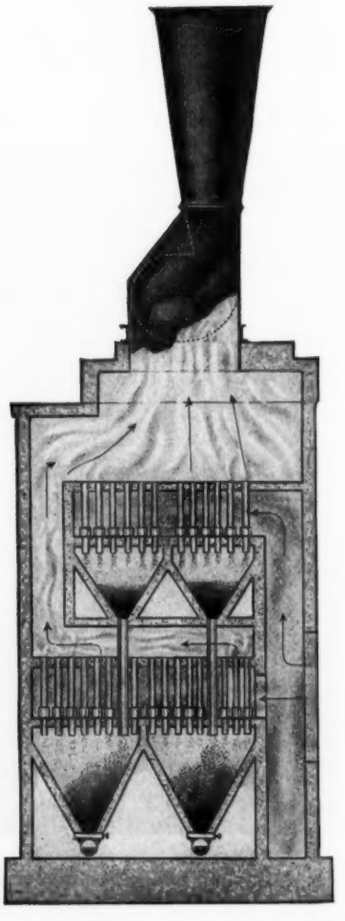

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Conservation in Design of Power Stations

By F. H. HOLLISTER

Chief Electrical Engineer, Sargent & Lundy, Chicago

IN THE design of electric generating power stations and associated transmission and distribution facilities, economics have always been balanced against conservative engineering. This was the practice in the past and undoubtedly will be in the future, but today not nearly so much stress is put on economics as on conservation. As a result of this greater effort for conserving critical materials, it is often possible to get along reasonably well without many refinements that were at one time thought to be absolutely necessary.

Many innovations resulting from the effort to conserve critical materials at the present time will be retained and improved in the future, and it is anticipated that there will be few 100 per cent reversions to previous practices and standards.

In these excerpts from a luncheon talk at the recent Midwest Power Conference in Chicago, the author reviews what has already been done to conserve steel and copper in the design of recent power stations and electrical structures and offers suggestions as to further savings should the War be of long duration. He ventures the prediction that many of these expedients will become future accepted practice.

Structures

Buildings for housing turbine-generators and steam generating units are now being designed, almost without exception, so that there are no walls between the turbine and boiler rooms. Although we first used this type of design for a power station near Sheboygan, Wis., in 1930, further economies and improvements have been made, and the general idea has been expanded in other new plants. The advantages obtained in reduced manpower, better vision, shorter distances and more efficient operation are only some of the desirable features of this type of construction. There are also the savings by reason of shorter steam and piping connections, less ground space, less building material and shorter and more direct cable and conduit connections to the many electrical motors and devices.

A similar major structural design feature used in three recently completed plants was the omission of the wall between the turbine room and the control and switchgear room. This arrangement has been restricted generally to plants up to about 10,000-kw capacity. Now that the reliability and safety of the metal-clad switchgear have been proved, the arrangement is being extended to plants of larger capacity. The possible saving in materials is obvious. The switchgear room as such, is merged into the turbine room; consequently, less overall ground space, less steel and less of other building materials are required.

Where there are no buses at generator voltage and the switching is installed outdoors, in some cases the arrangement and space are further simplified and conserved by installing the few necessary control panels adjacent to the turbine gage boards in the turbine room.

Further reduction in the amount of critical building material, such as steel for columns and for reinforced concrete, has been accomplished by omitting large sections of the floors in turbine rooms, leaving the turbine-generator sets mounted on large reinforced-concrete islands with narrow walkways around the machines.

In order to conserve steel, many new boilers are being served by reinforced-concrete or brick chimneys rather than steel stacks. It is estimated that, whereas a steel stack 100 ft high and 20 ft inside diameter would require about 30 tons of steel, a reinforced-concrete chimney of like dimensions would require not more than 10 tons of reinforcing steel. The steel stack with a brick lining costs more, but has a much longer life.

Power-station buildings and switch houses are now being built, some without windows and some with rectangular groups of glass blocks for windows, thus saving metal frames, lintels, and window operative devices. This type of building naturally requires some method of mechanical ventilation and air conditioning, but less tonnage of steel. As to the question of costs when windows are omitted, from estimates made, we find that with or without windows, the building costs are about the same, possibly 1 per cent more without windows. When the expense of the air conditioning provisions is taken into account, the differences in costs are appreciable. However, there are operating and maintenance advantages which make the closed type of building construction attractive.

Perhaps the latest development in connection with plans for saving critical materials is in making the superstructure columns and beams in power stations and switch houses of reinforced concrete instead of steel. General statements such as these do not mean much unless they are supported by actual figures. Here is one specific example: A two-story switchhouse 200 ft long by 50 ft wide and 40 ft high (400,000 cu ft), which is now being built of reinforced concrete, is estimated to require 30 tons of reinforcing steel for columns, beams and

girders. If steel were used as formerly, 120 to 130 tons would be required. This means a saving of from 90 to 100 tons of steel. It should be pointed out, however, that while there is a saving in steel, the use of reinforced concrete in the columns, beams and girders increased the physical dimensions of the building, and this increased the amount of copper required for buses and connections an estimated 1000 lb.

In the design of power house buildings there are several minor features which are being treated differently: Sections of floors are made of wood or of reinforced concrete instead of with steel plate or grating. Window frames are made of wood instead of steel. We are not so sure but that wooden frames are better under any circumstances because they are non-rusting and have longer life. Wooden frames probably have 40 yr or more of life if painted, whereas steel sash might rust out after less than 20 yr. Wooden stairs instead of steel are being used; also wooden handrails and wooden louvres are common. Walls made with brick instead of concrete save approximately 20 per cent in cost. It is, of course, recognized that the greater use of wood increases the fire hazard.

Turning to some of the features that belong more strictly to mechanical design, all of which were being considered but probably hastened by the War and have operated to conserve critical materials, we find that during the past year or so the factor of safety in stresses in the design of boilers has been reduced from approximately 5 to 4. Also, a short time ago the WPB asked the A.S.T.M. to liberalize the rating on valves and fittings, which no doubt will develop. Condensers are not being figured and designed to have less condensing surface for the same duty than heretofore. In some instances, where formerly structural steel would have been used for machinery bases, reinforced concrete is now used. Coal bunkers and ash hoppers in boiler rooms are being built of reinforced concrete, instead of steel plate. The saving in steel varies considerably according to the design but is on the order of a few tons per bunker. Practically no more space is required and equally as long life is expected.

Outside the power house buildings proper, structural supporting work in switch yards and substations is being designed to have wooden columns or posts, beams and braces. Probably the life will not be so long and there may be some checking and splitting of the wooden members, also a fire may spread more rapidly, although this possibility is reduced to a considerable degree by a fire-resistant treatment of the wood. The salvage value in a wooden structure is not as great as in a steel structure, but there is a considerable saving in steel, and that is all that matters at the moment.

Substitution of wooden pole construction in place of steel towers for new 69-kv, 138-kv and 230-kv transmission lines is being carried on extensively and considered generally throughout the country. The economy in the use of wooden pole lines furnishes a good point for argument.

Heretofore steel has been generally preferred for switchyards and lines because of availability, low cost and life. However, it is probable that in the future wood will be used more extensively for this purpose than before the War, as engineers will have become more accustomed to its use.

At this point, perhaps, it should be added that higher unit stresses in steel are now being employed and are permissible according to "WPB National Emergency Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings," dated September 10, 1942. That is, the permissible unit shearing stress has been increased from 12,800 to 14,000 lb per sq in., and the tension and bending stress from 18,000 to 24,000 lb per sq in. These changes will reduce still further the amount of steel used in future structures.

Electrical Design

Three years ago, in cooperation with the operating engineers, we designed a two-unit 50,000-kw plant using a 460-volt, loop bus in the boiler- and turbine-room basements for supplying power to the various motor-driven auxiliaries. The physical layout of the mechanical equipment in this plant lent itself to that scheme for distributing auxiliary power and we looked for not only a saving in overall costs but possibly as much as 20 per cent saving in materials compared to a radial system of distribution. In this there was disappointment when upon completion an analysis showed only a small saving. Subsequently, when we were laying out the auxiliary power distribution schemes for two other two-unit plants of like capacity, we considered a combination loop and network scheme, but after a very careful analysis were unable to show a saving in using these schemes for serving the power auxiliaries, although the differences were not large. We found that the location and size of the auxiliary motors were the determining factors and came to the conclusion that each plant warrants a careful study before adoption of any scheme of auxiliary power distribution and service.

Buses

Much can be done to conserve material in the selection and arrangement of copper shapes in buses. It has been our experience that one or two channels, as required, are the best adapted for very heavy current carrying requirements. On the basis of equal weights of copper, channels permit an increase in current capacity of about 50 per cent over flat bars closely spaced. Conversely, for the same current carrying capacity the sections of the channels can be reduced one-third. This is particularly true for currents of 2000 amp and upward.

We are now completing the design of a 10,000-kw two-unit plant with nine feeders using a single bus with metal-clad switching units. In ordinary times such a plant might have been designed with a double bus or a main and a transfer bus. In this particular instance, there was an estimated saving of 6600 lb of copper in bus and bus connections alone, and 28,000 lb of steel and other material, not including the materials in the breakers themselves.

For another plant where the design has been completed recently, transite has been used instead of steel for enclosing the bus and copper connections external to the switchgear cubicles. It was necessary to derate the capacity of the conductors somewhat because of the poorer heat radiation, but it was estimated that by using ventilated transite there was an overall saving in non-magnetic metal of approximately 20,000 lb.

It is of interest to note that WPB has prohibited the use of standard bus duct systems in industrial plants,

and for a given installation it is estimated there is a saving of 20 per cent in steel and 40 per cent in copper, due to the fact that the carrying capacity of copper can be increased considerably with open construction. This, of course, is accomplished at the expense of safety and reliability.

In outdoor switchyards where there are currents of low values on the order of 200 and 300 amp, steel pipe and structural steel shapes have been used for buses in place of copper bar or tubing. The amount of copper saved depends, of course, upon the extent of the installations.

There have been some scattered notices in the press concerning the use of silver instead of copper in buses. Quoting from *Public Power* of November 2, 1942:

"The WPB said 24,000,000 lb of copper, enough to make 95,000,000 aircraft machine gun bullets, 1,500,000 anti-aircraft shells, and 600,000 anti-tank shells, has been saved in ten war plants now being built through substituting silver in electrical conductors."

Cable

Cable applications constitute one of the fields in electrical work where considerable action has been taken primarily for conservation of copper. Cable applications appear to hold the most uncertainties and indeterminants.

Where cables are installed in pans or ducts, considerable saving in critical materials has been effected by omitting the interlocked armor—bronze and steel—from the cables and using as a substitute a lead covering with a protecting treated braid, or in some places a rubber or synthetic covering. While the alternates do not give the same mechanical or electrical protection, the expedient saves much metal material and at the same time is cheaper.

As another important step in the conservation of cable and copper, engineers are giving more attention to the selection of cable sizes and the number of reserve feeders. Closer analyses are made of the expected loadings and demand factors so that in many instances smaller cable sizes are used or cables omitted.

Switchgear Units

Designing engineers and manufacturers of electrical equipment have spent considerable time and research during the past fourteen years, in the design and application of the so-called factory-built switching and control units or cubicles. To a large extent the units have been developed around the idea of enclosing the equipments with metal, installing barriers between the buses and phases of the units and substituting metal for slate and ebony asbestos for mounting switches, instruments and controls. The primary purposes of this innovation have been to furnish greater protection to operating personnel, to stop the spread and to limit the extent of the danger from electrical failures, also to reduce the labor cost and time for installation in the field.

The unit type of equipment has opened up new avenues for further development in the application and use of electrical switching, particularly by saving copper at the expense, to some extent, of sheet steel. Copper buses and connections are made much shorter, but retain the important features of protection to personnel and equipment.

Switches

In some plants fused knife switches, which were in common use 25 years ago, are now being employed on low-voltage auxiliary power circuits instead of air circuit-breakers. With this type of switch there is some saving of critical material, but because of the possibility of single-phase operation and its attendant dangers, also the hazard to the personnel when replacing the fuses and the inadequacy of fuses for selective tripping, the use of fused switches in many applications will be discontinued and replaced when air circuit-breakers again become available.

Transformers

One of the interesting changes or developments in transformer design has been the improvement in ratings accomplished by the addition of fans to accelerate the cooling of oil in self-cooled transformers, particularly in units of 1000 kva and larger. Transformer manufacturers generally agree that the 55 C ratings of transformers below 2500-kva capacity can be increased 25 per cent and that, in units of 2500 kva and larger, the ratings can be increased from 25 to 33 per cent by this means. Naturally, where there is a shortage in capacity many old transformers are being equipped with fans for that purpose. In some instances it has been proposed to circulate the oil through a separate heat exchanger where the temperature-reducing agent may be either air or water.

Two other important self-evident moves to save critical materials in transformers are the omission of the so-called spare transformers and the installation of three-phase instead of three single-phase transformers. Transformers in general are so reliable and failures so few that it is a debatable question if any considerable risks are being taken. From 15 to 20 per cent of material, including copper and steel, is being saved when three-phase transformers are substituted for three single-phase transformers.

Motors

Most of us have had something to do recently with the application of motors under WPB Limitation Order L-221, and there is not much that needs to be said about conservation of motors as applied to power house auxiliary drives.

Where previously motors with conservative ratings were selected to assure ample capacity and longer life, engineers are now conforming to WPB Limitation Order L-221 and selecting open-type motors where applicable, with ratings at approximately 80 per cent of the maximum determined horsepower demands. However, in addition, we have followed the practice of making a thorough check on possible ambient temperatures and then being guided accordingly in specifying the motors to be used.

As an example of possible prevailing temperatures, in one power station where a 50,000-kw turbine-generator unit and two 250,000-lb boilers were installed last summer, the ambient temperatures were found to be as follows: with air outside of 100 F or 38 C, the temperature in the turbine room basement was 50 C, in the boiler room it was 55 C, and in the penthouse over the boiler room it was 82 C. In such an installation, motors would be selected that would have total temperatures at

rated full load corresponding to the maximum allowed by A.S.A. In certain cases the problem is best solved by the use of Class "B" insulation.

LIGHTING

In the field of lighting, one change that has been made which conserves copper and iron has been the use of the filament unit instead of the fluorescent unit for the lighting of operating rooms, turbine and boiler gage boards, and in other places. Lighting luminaires are now being made with pressed steel housings with chromium plated inner surfaces which have a higher reflection factor than enamel—taking the place for the time being of aluminum and enameled reflecting surfaces and thus conserving critical materials.

Conclusion

As to the future, one may ask in what direction or in what other particulars should we look for further developments in the interest of conservation, particularly if the War should continue several years. In this respect the following are suggested:

1. The design and construction of power plants where the steam turbine and steam generating units are either wholly or partially installed outdoors.
2. An extension in the range of use of hydrogen cooling in electrical machines.
3. The substitution of reinforced concrete for steel in building superstructure columns, beams and girders.
4. Omission of windows from power and switchhouses and improvements in air conditioning.
5. Development of new simplified systems for auxiliary power distribution.
6. Use of silver in the replacement of copper for buses in more places should the War continue for a long period.
7. More economical use of cable and elimination of duplicate feeds and ties with the improvements in protective devices.
8. Operation of cables at higher temperatures after further research and operating experience to check on the probable life.
9. Use of protective devices in electrical work to a greater degree, thereby making it possible to simplify the electric system and use less primary copper.
10. Improvement in artificial cooling of transformers with air.
11. The cooling of switchgear with air to increase current rating either by circulation of air in the room or by forced filtration through the equipment itself.
12. Extension in the use of common frame single-tank oil circuit-breakers, also of air circuit-breakers.
13. Development of better and cheaper metallic and non-metallic surfaces in lighting luminaires.

Facts and Figures

(Suitable items for this column will be welcome)

The highest pressure ever applied commercially to a marine boiler in service on shipboard was around 1900 psi.

•

Approximately one-third the total industrial power load is supplied by private industrial power plants.

•

Bureau of Reclamation power plants supplied nearly one-fourth of all the electricity used by war industries in the Far West during 1942.

•

During March 1943 the capacity of electric generating plants in the United States showed a net increase of 182,610 kw, making the total installed capacity 47,180,338 kw.

•

Measured in tonnage, the bituminous coal industry is the largest in the United States, it being six times as great as that of steel.

•

The first diesel-propelled ocean-going ship, the *Selandia*, which attracted worldwide attention at the time of her completion thirty years ago, has at last fallen victim to the Axis submarines.

•

Despite the fact that the present capacity of the steel industry in this country is estimated to exceed half that of the entire world, current demands are such that 1943 scrap requirements have been raised to 25 million tons, a considerable portion of which will be needed by the middle of the summer.

•

Higher rates of heat release per cubic foot of furnace volume are generally more permissible with small furnaces than with large. This is because the wall surface exposed to radiant heat in the small furnace bears a higher ratio to the volume than in the case of the large furnace.

•

As insurance against power shortage in any coastal or navigable river area, due to drought or other cause, the Power Division of WPB is having constructed a number of floating power plants of 30,000 kw each, which can be towed from place to place as needed.

•

To encourage the burning of used and reclaimed lubricating oil, such as crank-case oil from gasoline engines, the OPA has exempted such oil from rationing regulations. In general, such oil can best be substituted for the heavier types of fuel oil as burned under power boilers or in industrial furnaces.

Heating System for Naval Warehouse Employs Minimum Critical Materials

Stoker-fired air heaters, burning anthracite, full automatic control to save manpower, timber coal bunkers, transite casings, asbestos-cement-board ducts and a concrete plenum chamber were employed to achieve this purpose. Compared with a conventional steam heating system, the weight of metal per million Btu per hour output is reduced to less than one-third.

By BERTRAM B. REILLY,
Research Engr. Heater Section,
Dravo Corporation, Pittsburgh, Pa.

HOW adequately to heat large enclosures is normally no simple problem from the engineer's point of view due to the many physical requirements which must be met, such as even heat distribution, economy of operation, minimum space, etc. This problem has been further complicated during the present emergency by the presence of several additional factors, most important of which are restrictions upon the use of critical materials, the type of fuel which can be burned in various sections of the country, and the manpower shortage. The last mentioned makes it advantageous to employ completely automatic equipment, if possible, when complying with the restrictions placed on materials and fuel.

The Bureau of Yards and Docks of the Navy found a solution to these problems in the design of heating system for various warehouses recently erected. Briefly, the installation here described consists of two Dravo direct-fired air heaters per warehouse, with non-metallic duct distributing systems supplying warm air to various sections of the warehouse. Each heater is fired with a C-E Skelly stoker unit, arranged for burning of anthracite rice coal as a base fuel. Alternate parts for the stoker were furnished for burning bituminous coal where desired. The coal is stored in a bin beneath the stoker-room floor and is fed from this bin to an overhead storage hopper by means of a bucket conveyor. No manual handling of the coal is required from the time it is dumped from the trucks into the underground bin until it is finally burned in the furnace.

The actual computations and design of the heating

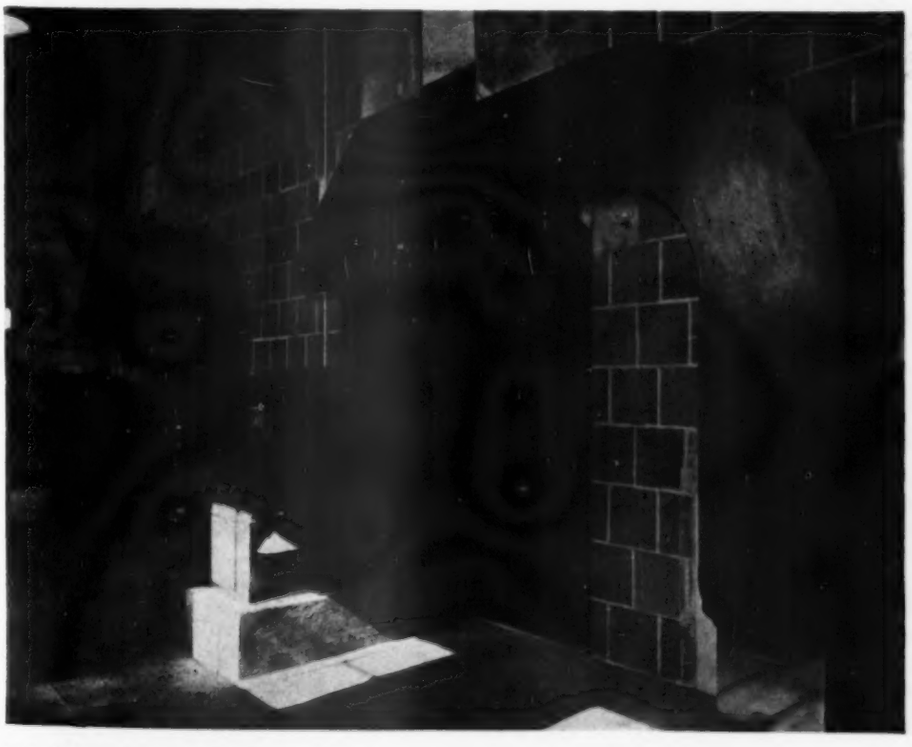


Fig. 1—Stokers and fronts of heaters

Fig. 2—Plenum chamber in which heater and fan are located

system for these warehouses were performed by the Bureau of Yards and Docks of the Navy; and in order to avoid the possibility that the information might be of any aid to the enemy, quantitative data have been omitted from this description, as well as identification of the installation described. Hence, all information is given on a relative basis or a unit basis.

The storage portion of these warehouses is divided by firewalls into four storerooms. The two end rooms occupy about 26.6 per cent of the space each and the two center storerooms about 23.4 per cent each. Included in one storeroom is the utility section occupying 1.33 per cent of the space in the building. This utility section is independently heated by a small forced-circulation hot-water system. The average ceiling height is about 19 ft exclusive of the large glazed monitors.

One of the original layouts provided steam unit heaters fed from twin cast-iron boilers, while the other provided hot-air furnaces delivering into masonry ducts below the floor for distribution. The hot-air furnace system was finally adopted because a considerable saving in critical materials would be effected as compared with a steam system. In order to avoid a complicated underground masonry duct system, the hot-air distribution arrangement was changed to use overhead non-metallic duct distribution.

Tests

One of the Navy requirements on this installation was a capacity test to determine whether the equipment furnished had sufficient capacity to develop the required output. In view of the fact that there has been no standard test code for heavy duty air furnaces, the following test procedure was decided upon.

The method of testing consisted of an accurate measurement of the total input to the heater, determined by the weight of fuel fired and the heating value of the coal per pound. The output of the heater was determined as the difference between the heat input and the heat losses comprising moisture in coal, water formed by combustion of hydrogen in coal, moisture in combustion air, dry chimney gases, unburned combustible in flue gases, and unconsumed combustible in the refuse. A test was conducted in accordance with this procedure with

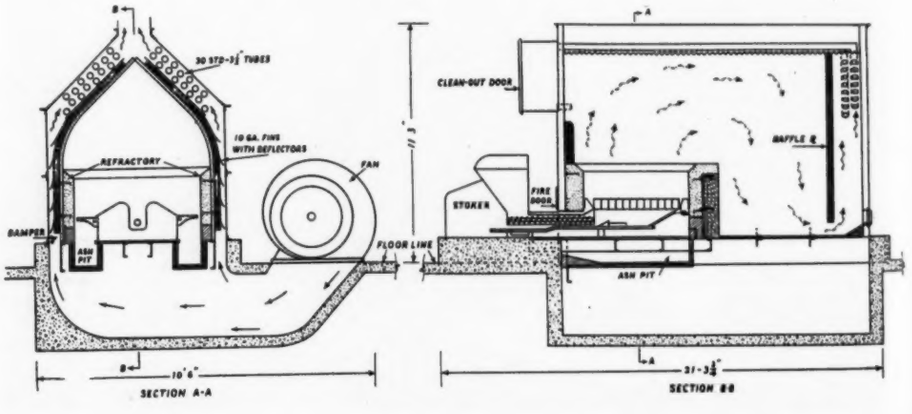


Fig. 3—Sections through heater and furnace

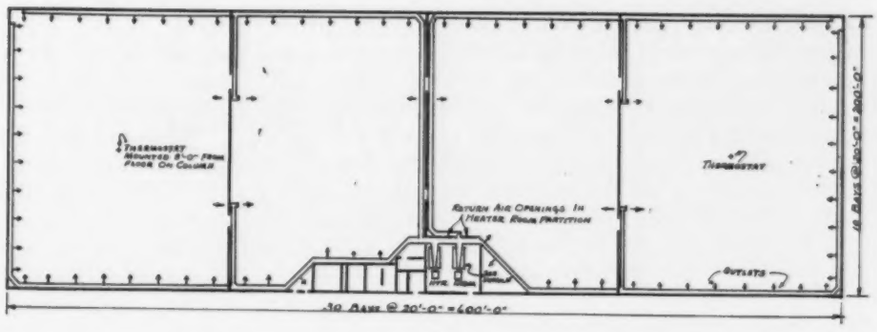


Fig. 4—Plan showing distribution of heated air

results as given in the accompanying tabulation.

This test indicated a total output capacity of practically 25 per cent above the specified capacity, which was 4,000,000 Btu per hr. Considering that this was a maximum output test rather than an efficiency test, the efficiency obtained was good. If the test had been made at rated capacity rather than 25 per cent overload, the efficiency would have been considerably higher, due to lower temperatures of the gases leaving the heater. The fineness of the coal and its high ash content account for the loss of carbon in the refuse.

TEST OF ANTHRACITE COAL-BURNING TYPE DIRECT FIRED HEATER

HEATER, Dravo No. 400-GHMA
DATE OF TEST, March 23, 1943
DURATION OF TEST, (7) hr
STOKER, C-E Skelly, Size 5C72
GRATE AREA, 30 sq ft
KIND OF COAL USED, No. 2, Buckwheat (rice) anthracite

Measured Test Data

Coal consumed, as fired, lb	3,759
Higher or gross heat valued, as fired, Btu/hr	12,620
Weight of solid refuse, lb	564
Temperature air entering fans, deg F	60.5
Arithmetical average of temperatures of air leaving heater, deg F	189.9
Average temperature of air entering stoker fan, deg F	64.5
Average temperature of gases leaving furnace, deg F	702.0
Moisture content of air entering stoker fans, gr per cu ft	5.0
Static pressure in air plenum chamber of heater, in. of water	2.25
Average static pressure at heater discharge, in. of water	1.00
Static pressure at intake to induced-draft fans, in. of wa er	1.25
Over-fire draft, in. of water	+0.01
Under-fire draft in. of water	1.51
Power input, average kw	22.2

Proximate Analysis of Coal

	As Recd.	Dry
Moisture, per cent	4.37	..
Volatile, per cent	3.40	3.55
Fixed Carbon, per cent	82.09	85.83
Ash, per cent	10.14	10.62
	100.00	100.00
Btu per lb	12,620	13,208

Ultimate Analysis of Coal

	As Recd.	Dry
Moisture, per cent	4.37	..
Carbon, per cent	80.95	84.65
Hydrogen, per cent	1.82	1.91
Oxygen, per cent	1.21	1.27
Nitrogen, per cent	0.86	0.90
Sulphur, per cent	0.64	0.67
Ash, per cent	10.15	10.60
	100.00	100.00

Proximate Analysis of Refuse

Combustible, per cent	36.18
Ash, by difference, per cent	63.82

Analysis of Dry Flue Gases

Carbon dioxide (CO_2), per cent	12.0
Oxygen (O_2), per cent	6.7
Carbon monoxide (CO), per cent	0.0
Nitrogen (N_2) by difference, per cent	81.3

Calculated Values (All values based on coal as fired)

Weight of coal as fired, per hr	537
Refuse, per hr	80.6
Refuse, per cent of fuel as fired	14.9
Carbon burned per lb. of fuel	0.7585
Dry gas per lb of fuel	15.85
Air supplied per lb of fuel as fired	15.16
Moisture in air, lb per lb of air	0.0095
Heat output (calculated by difference method), Btu per hr	4,980,000
Excess air, per cent	45

Heat Balance

	Btu per Lb. as Fired	Per Cent
Heating value	12,620	100
Heat loss due to moisture in coal	58	0.46
Heat loss due to water from combustion of hydrogen	220	1.74
Heat loss due to moisture in air	43	0.34
Heat loss due to dry chimney gases	2,430	19.27
Heat loss due to incomplete combustion of carbon	0	0.00
Heat loss due to unconsumed combustible in refuse	577	4.57
Total Losses	3,328	26.38
Efficiency by difference		73.62
Balance to air stream and radiation*		

* Radiation not considered a loss since it goes into useful heat by raising the temperature of air entering heater.

Conservation of Critical Materials

An interesting sidelight on the installation is the weight of critical material required. The job as installed required slightly less than 6000 lb per million Btu per hour rated output. On the basis of developed output on the test this weight dropped to approximately 4700 lb per million Btu per hour output. In comparison with this, a complete steam-heating system including boilers, stokers, steam piping, unit heaters, etc., would normally run in the neighborhood of 16,000 lb per million Btu per hour output.

Description of Installation

Two heaters were installed for each warehouse, arranged so as to discharge the hot air into a common duct header. The supply ducts from this header were run around the entire outside wall of the warehouse and

branch ducts were also run along the fire-wall partitions within the warehouse (see Fig. 4). By using a common header either of the units can be operated alone in mild weather rather than to operate the entire setup. The heating units are of the blow-through type with centrifugal fans mounted on the floor alongside the heater, and discharging into a plenum chamber beneath the heating units. The air passes from the plenum chamber up over the finned corrugated heating surface of the units and then over the secondary surface of the convection tube to the heater discharge. The warehouse area is open to the fan room with a large screened opening provided for passage of the return air from the warehouse to the fan units. The entire fan room is partitioned off from the stoker room to avoid any possible contamination of the supply air with coal or ash dust which might come from that source.

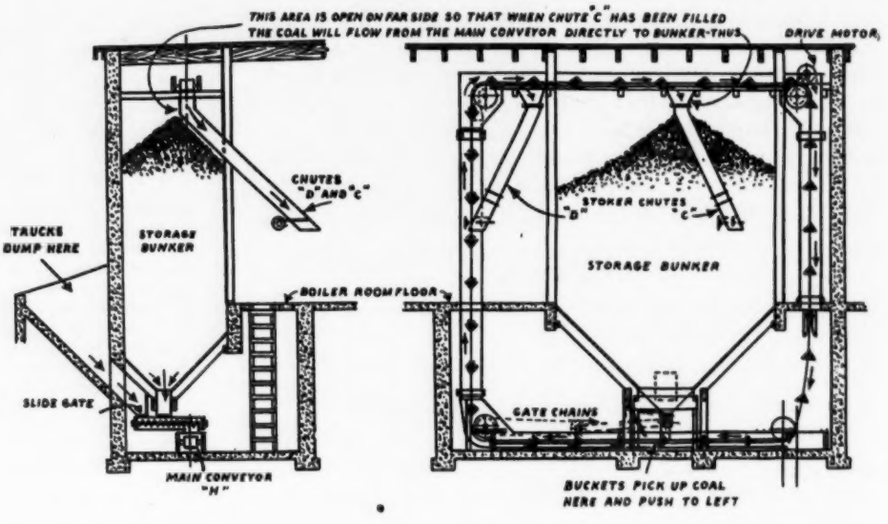

THIS AREA IS OPEN ON FAR SIDE SO THAT WHEN CHUTE "C" HAS BEEN FILLED THE COAL WILL FLOW FROM THE MAIN CONVEYOR DIRECTLY TO BUNKER-THUS
DRIVE MOTOR
CHUTES "D" AND "C"
TRUCKS DUMP HERE
STORAGE BUNKER
BOILER ROOM FLOOR
SLIDE GATE
MAIN CONVEYOR "H"
STOKER CHUTES "D" "C"
STORAGE BUNKER
GATE CHAINS
BUCKETS PICK UP COAL HERE AND PUSH TO LEFT

Fig. 5—Section through coal-conveyor system

The stokers are of the underfeed type, equipped with moving and stationary grate bars and cantilever dump grates arranged for continuous disposal of ash to the ash-pit. They were arranged for burning anthracite rice coal as a base fuel, but accessory conversion parts have been provided for conversion to permit the burning of bituminous coal if desired. These parts consist of a complete set of dump grates, a feed worm and a reciprocating ram.

The coal handling problem was solved by the use of the conveyor system previously mentioned. The ceiling height of the building in the vicinity of the stoker room is only about 17 ft. It was, therefore, necessary to adopt a rather unique design in order to get adequate storage below the ceiling and still have the storage 100 per cent available for automatic feed to the stoker. The scheme adopted is shown in Fig. 5. A concrete receiving hopper of approximately 5 tons capacity is provided outside of the building into which the trucks dump. From this hopper coal is automatically fed by a screw feeder at the rate of about 15 tons per hour to the lower horizontal run of the main conveyor. This consists of V-buckets mounted between two strands of rivetless steel chain, the conveyor being so designed as to push the coal along on the horizontal runs and carry it in the buckets on the ascending run. The coal is thus taken from the feeder, hoisted vertically on the ascending run and conveyed horizontally on the top run, which passes directly over the intakes of the two spouts leading to the stoker hoppers.

When starting the equipment initially, the conveyor delivers the coal first to the stoker chute *D* and when this chute has been completely filled, the coal is diverted through the open back of chute *C* into the main storage bin. When the coal from the latter is to be used, it is carried from the bottom of this bin by the screw feeder to the lower run of the conveyor, carried again to the top, and discharged into the stoker chutes. The capacity of the main storage bunker is approximately 37 tons, gravity fill, and each stoker chute combined with the stoker hopper proper gives an additional storage of about 1100 lb. With this arrangement a total storage of about 43 tons is provided in the extremely limited space.

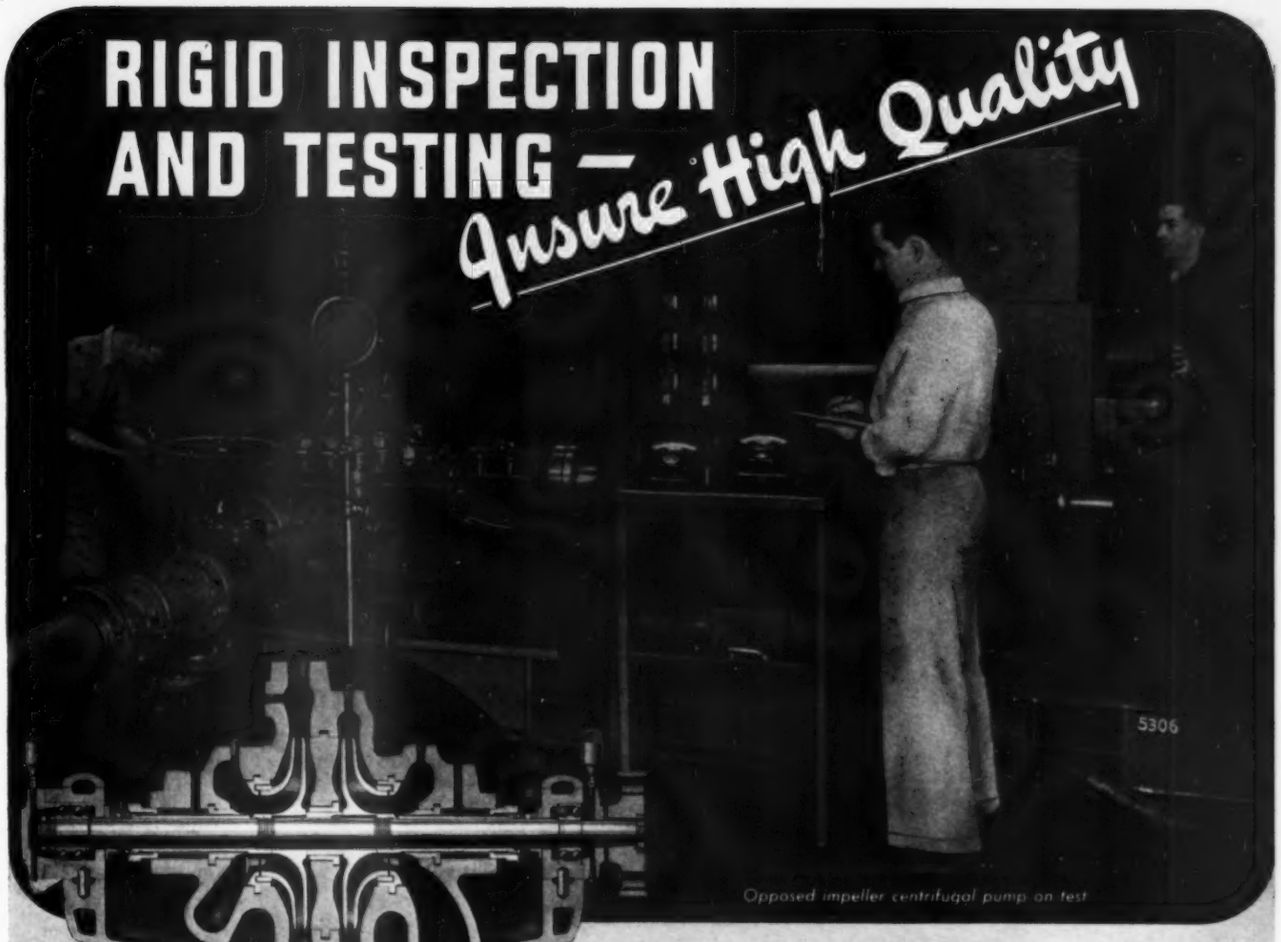
It should be noted that throughout the installation, in order to conserve critical material, a great many items normally constructed of metal were made of non-critical materials. The entire duct distribution system, for example, is of asbestos-cement board using only a small amount of metal for joints and hangers. The coal bunkers are of timber throughout and vertical casings for the conveyors are of timber and transite. The fan arrangement permits the entire fan discharge plenum to be constructed of concrete, so designed as to be incorporated as part of the heater foundation.

Conclusions to be drawn from the successful test and operation of this anthracite-fired, hot-air central-duct type of heating system are that limitations imposed on fuel, material and labor can all be overcome to produce an efficient, reliable heating plant, which in many respects has marked advantage over conventional systems.

Acknowledgment

The author wishes to express his appreciation of the assistance rendered in the preparation of this article by C. H. Gardenier, Chief Mechanical Engineer, John W. Cowper Company, and E. P. Dandridge of the E. P. Dandridge Company, manufacturer of coal handling equipment.

RIGID INSPECTION AND TESTING — Insure High Quality



Opposed impeller centrifugal pump on test

Axial section of the pump

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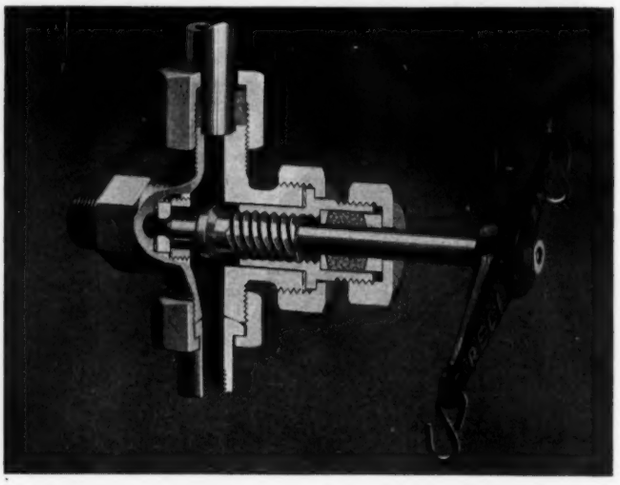

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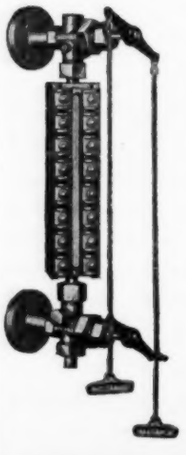

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Power and Fuels Discussed by Chamber of Commerce

The present situation with reference to meeting war and domestic demands for power, coal, oil and gas was discussed separately by authorities in these respective fields. Their talks were followed by a round-table discussion in which timely questions were answered by a panel of experts. The outlook was regarded as generally satisfactory, except that unpredictable military demands obscured any conclusions as to the future oil situation.

THE importance of power, coal, oil and gas in prosecuting the war was stressed at a special luncheon session on April 28 during the Annual Meeting of the U. S. Chamber of Commerce at the Waldorf-Astoria, New York.

With J. D. Francis presiding, the program included talks on "Pooling Power for War" by Kinsey M. Robinson, President of the Washington Water Power Company; "Coal Preparedness" by C. C. Dickinson, President of the National Coal Association; and "What About Oil and Gasoline" by Howard Marshall of the Office of Petroleum Administration for War. There followed an informal panel discussion in which questions on power were discussed by W. E. Mitchell, Vice President of the Georgia Power Company; on bituminous coal, by Grant Stauffer, President of the Sinclair Coal Company; on oil, by E. Holman, Vice President of the Standard Oil Company of New Jersey; on anthracite by Gordon C. Cooke, President of the Delaware, Lackawanna & Western Coal Company; and on gas, by Thomas J. Strickler, Vice President of the Kansas City Gas Company.

Mr. Robinson pointed with pride to the fact that the electric utilities, through foresight in promoting interconnection, pooling and regional systems, had been able to meet all demands, despite the erroneous predictions of the Federal Power Commission. To this readiness and ability to serve, he attributed the fact that no utilities in Continental United States had been taken over by the Government, and stated that they are now actually subjected to less governmental control in their operations than are many other industries. Private power is now supplying seven-eighths of the present demands. A disturbing thought, in view of certain attempts to socialize industry, is the fact that the Government now has 15 billion dollars invested in productive industrial facilities and this figure is likely to reach 26 billion before the end of the war.

Mr. Dickinson said that, despite inroads made by the draft, absenteeism and the pirating of labor by war industries, the bituminous coal industry was able to produce 580 million tons in 1942, which was 20 million tons above what the Government had requested. This year it was hoped that the total production could be stepped up to around 640 million tons. The heavy inventory of 90 million tons in the hands of consumers and dealers last year had proved a helpful stabilizer. He mentioned, however, that much mining equipment had been overworked and that considerable new equipment would be needed. Although the coal now being mined is that most readily obtainable, the coal industry in 1942 operated on a thin margin of profit of 9.24 cents per ton on an investment in plant of approximately $5 per ton.

Mr. Marshall prefaced his remarks by describing the organization of the Petroleum Administration which had been kept to a minimum, had drawn its personnel from the petroleum industry and had worked largely through committees of that industry—all with the idea of not building up a bureaucracy, but rather an organization that could be self-liquidated almost immediately upon termination of the war.

Since completion of the 24-in. pipe line from the oil fields to Norris City, Ill., which made for shorter tank-car haulage to the Atlantic Seaboard, the daily delivery to the East had been stepped up to 1,200,000 bbl. A second line of 20 in. diameter is now under construction to handle refinery products. These pipe lines were engineered and built by the oil industry with funds loaned by the Reconstruction Finance Corporation.

The speaker pointed out the impossibility of forecasting the situation in the East, as overseas demands are unpredictable. The present total demand at the rate 1,400,000,000 bbl per year could not be sustained for more than a couple of years, and possibly less, without the discovery of new fields. Although there are no bottlenecks in the refining of ordinary products, scarcity of materials has presented some problems in meeting the demand for high-octane gasoline.

Round Table Discussion

Power

In response to questions as to the adequacy of power supply and the success of power pooling when both public and private sources are involved, Mr. Mitchell reiterated that no essential customer has yet failed to have his power requirements met and that the utilities are in even better position to meet demands of the next twelve months than the past like period. Interconnection with TVA in the South had worked out satisfactorily and the present policy in that section is to utilize to the fullest extent all available hydro power in order to conserve fuel.

As to the effect of the 48-hr week in the operation of electric utilities, Mr. Mitchell stated that, in many classes, it did not release men but added 30 per cent to the payroll. As to taxation, he stressed the point that "power to tax is power to destroy" and pointed out that increased taxes plus increased operating expenses had resulted in less net earnings than prevailed ten years ago, despite larger gross earnings. Invested capital in the industry is seven times the gross earnings, with little turnover.

Oil and Gasoline

Asked if the two new pipe lines from Texas to the East Coast would bring enough petroleum to give motorists and oil-heated homes more oil, Mr. Holman stated that the Atlantic Seaboard normally consumes about 1,500,000 bbl of oil per day and that by the end of this year, 1,600,000 bbl per day would be coming in. However, in view of the uncertain military demands, no definite answer could be made to this question; although he had reason to hope that consumers would receive as much heating oil as they did last winter. There had been an increase of ten per cent in refinery runs, but the demand for residual oils for the Navy and Merchant Marine is ever-increasing, and it is certain that there will be no greater amount of gasoline available for pleasure driving.

As to the charge that the oil industry is monopolizing the production of synthetic rubber, the speaker stated that, if all the rubber normally required in the United States were to be made from oil, it would account for only one-half of one per cent of the oil output. Moreover, the oil industry is primarily concerned with rubber tires being available from any source as it means the sale of gasoline. He pointed out that production of synthetic rubber from farm products is very much more expensive than from petroleum.

Replying to a specific question as to why his company had turned over to the Government its patents on synthetic rubber, Mr. Holman said that even though

MORE STEAM

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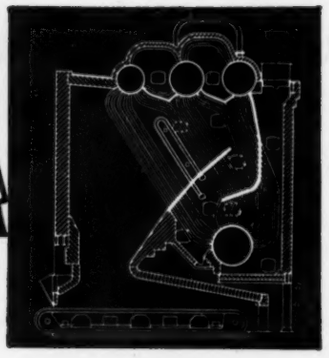

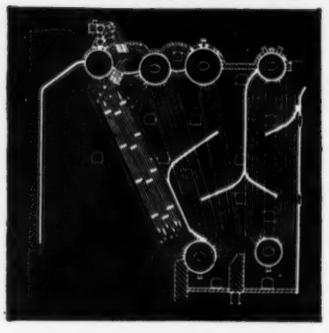

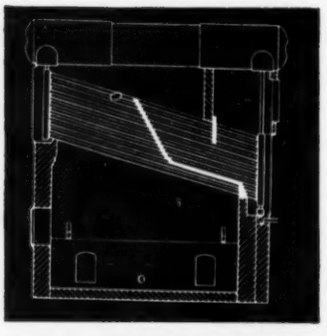

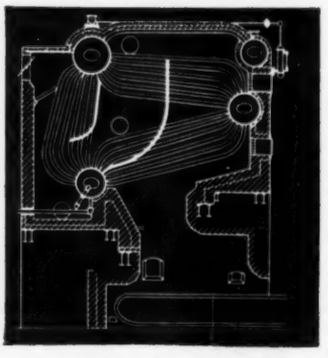

Demands for greater boiler output are often met by installing more efficient baffles.

Overload operation need not be destructive nor cause serious outages due to furnace failures when the heat path through the boiler is well designed.

Enco baffling boosts steam output safely. The cross flow puts every foot of heating surface to work. The streamlining prevents eddy currents and dead gas pockets.

Enco baffles also cut down draft loss by doing away with bottlenecks in the passes. They save steam because soot blowers are used more effectively and less often. They can be applied to any water-tube boiler.

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Enco Streamline Baffles

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these patents were freely available during the war, the action had been taken in response to Mr. Jeffers' suggestion that others might hesitate at making the necessary investments in equipment for the manufacture of synthetic rubber unless assured that the rights to use the processes would be unhampered.

Gas

Mr. Strickler stated that the gas industry is now operating at its peak with a yearly rate of 3 trillion cubic feet of natural gas and 500 million cubic feet of manufactured gas, of which 15 per cent of the total is used in war industries. It has not been necessary to cut off any domestic consumers nor gas to any essential industries but, in some cases of non-essential use, cut-off clauses for certain periods have been invoked in the interest of conservation; and, in a few instances along the Eastern Seaboard and in the Northwest, manufactured gas had been curtailed because of lack of petroleum. Increased coal and labor costs are becoming serious in the case of manufactured gas with the OPA blocking increased rates to consumers.

Anthracite

Mr. Cooke, in reply to several questions, stated that last year's output of 52,200,000 tons would likely be stepped up this year to about 62,500,000 tons, providing the necessary man-power for mining operations is available.

Two-thirds of the output goes to the domestic market and one-third to the railroads and industry. This estimated increase in production is not enough to take care of any very large increase in the number of conversions. He advised against consumers attempting to store a full year's supply at the present time, as this would be impracticable from the standpoint of production. Instead, he advocated storing about 40 per cent by the end of the summer and the remainder could be taken in periodic shipments in order to keep the mines operating at an even output. The added needs of war plants and the Army do not interfere with the domestic supply as sizes different from those generally used by residential consumers are involved.

Bituminous Coal

In view of very little storage capacity at the mines, Mr. Stauffer advised bituminous coal consumers to start building up their reserves, as the railroads are in better shape to haul large quantities of coal in summer than in winter.

Replying to a question concerning wages in the coal industry, he said that there are only five other major industries with higher hourly rates, although last year the miners' total earnings were not so high because of their 35-hr week. Now with a longer work week involving overtime, their earnings should range from $45 to $50 per week.

As to rationing of bituminous coal, Mr. Stauffer did not anticipate that it would be necessary, although the Solid Fuels Administration has a plan ready if such action should become necessary because of some unforeseen conditions.

Charles E. Walsh (left) congratulating A. J. Moses (right) while President Santry looks on

Combustion Engineering Awarded Second "M" Star

In recognition of continued outstanding service in the production of marine boilers, the Hedges-Walsh-Weidner Division of Combustion Engineering Company, Inc., was awarded the "Gold Star" for its "M" pennant by the Maritime Commission at an appropriate ceremony in Chattanooga on April 22.

The award was made by Charles E. Walsh, Director of Procurement for the Maritime Commission, who alluded to Admiral Land's remarks at the time of the "M" pennant presentation last September in which he stressed the need for ever-increasing production of boilers to meet the needs of our shipbuilding program and President Santry's promise to exceed previous achievements. This promise, Mr. Walsh said, had been fully kept. He then reviewed the shipbuilding situation, pointing out that nearly 19 million deadweight tons of ships will be built this year, making a total of 27 million tons for the two years since the present program had been initiated.

Mr. Walsh warned that, "Carelessness or complacency on the part of any man or woman on the production front can be fatal to our seamen and men on the fighting lines," and continued, "the sentry who sleeps on his post is subject to execution, while the man who does less than he can in our shipyards and factories can only be driven to do his best by his own conscience."

The award was accepted by A. J. Moses, Vice President and General Manager of the Hedges-Walsh-Weidner Division of the Company, who regarded the gold star as something placed in the keeping of the workers at this plant, to be retained only as long as they were worthy of it. "This is America's challenge to each and every member of the division at Chattanooga," he said, "who were there to rededicate themselves to a new and finer sense of duty."

After the raising of the pennant, J. V. Santry, President of Combustion Engineering Company, spoke briefly on the "Challenge of the Award." He referred to his statement to Admiral Land when accepting the challenge of the Award in September of 1942, at the time of the Maritime "M" Flag presentation; namely, that at the end of six months our production would be such that we would be awarded the Star for Meritorious performance and thanked the employees for making good his promise.

He added that the total number of Liberty boilers shipped from this plant up to April 1 approximated the total number of boilers installed on all Liberty Ships commissioned to that date and cited that production of these boilers was now at its maximum and well ahead of scheduled requirements. He referred to the fact that shipyards using these boilers had commented on the excellent workmanship and congratulated the employees for this, which resulted in many man-hours saved on necessary assembly and installation work performed by the yards.

On behalf of the employees he promised that the same meritorious performance would be continued and that future production would be the maximum that it was humanly possible to produce with the facilities at hand.

N.D.H.A. Meeting at Pittsbugh

The 34th Annual Meeting of the National District Heating Association will be held at Hotel Schenley, Pittsburgh, Pa., June 9 and 10, 1943. This will be strictly a technical meeting devoted to war-time problems of the steam utilities. Twelve technical committees will report and 28 papers will be presented on various phases of the industry.

Store Coal *safely . . . rapidly . . . economically . . .*

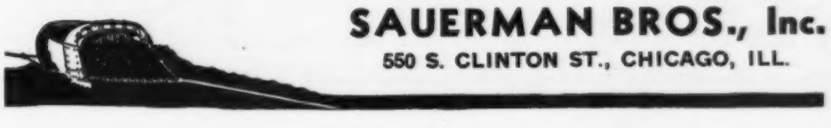
SAUERMAN Power Drag Scraper Systems permit simple, low-cost installation and operation. Efficient for storage areas of any size or shape.

One man operation, under clean, attractive conditions, assures low cost, thrifty handling of every ton of coal in and out of storage. Eliminates all heavy equipment. Sauerman equipment will build a perfect, homogeneous pile as high as desired. Avoids segregation and combustion hazards of air pockets and chimneys. Meets every capacity requirement.

No other method of coal handling and storage can compare with Sauerman low-cost efficiency and safety.

An interesting booklet has been prepared describing Sauerman Scraper Systems. Your request will bring you a copy of this booklet by return mail.

This ¾ cu. yd. scraper installation at a cement mill handles an average of 200 tons of coal per day, either storing or reclaiming, but when heavy shipments are arriving, stocks out as much as 450 tons per day. Present storage of 8000 tons on 35,000 sq. ft. is by no means maximum which scraper can store on this space. Plant formerly used overhead crane, piling in runway. The Sauerman scraper provides increased capacity at less cost and old runway becomes storage space for the mills' crushed rock supply.



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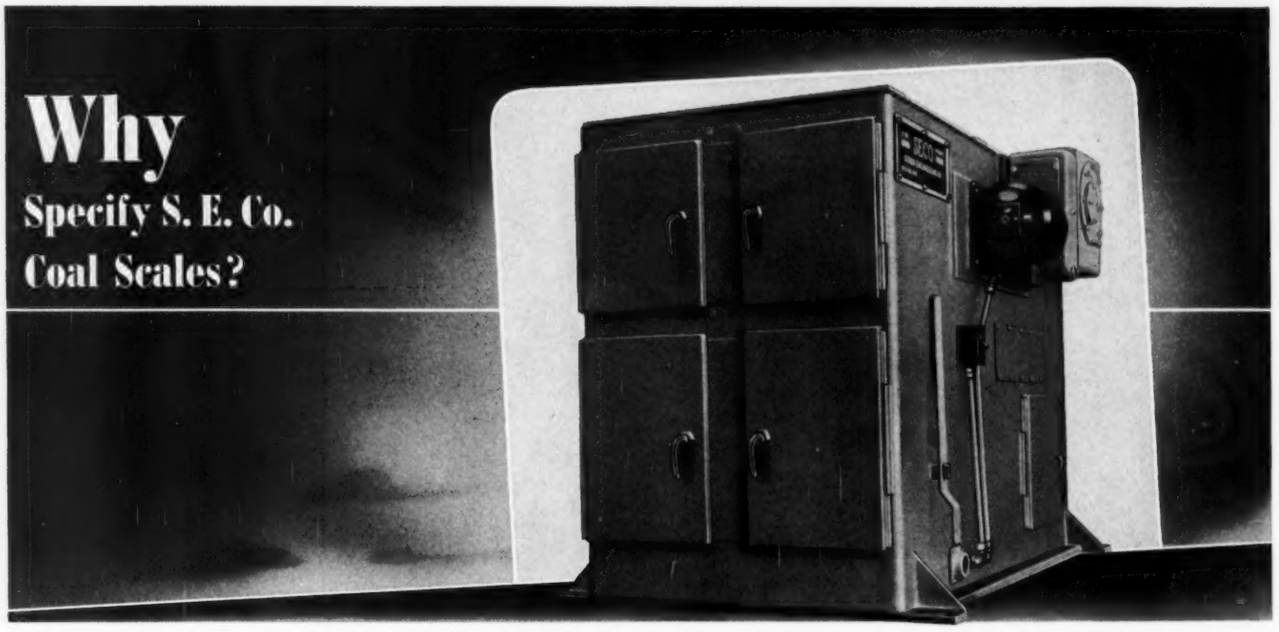

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BOOKS

1—Works Boiler Plant

By F. J. Matthews

181 pages Price $4.00

This book is offered as a guide to the operation and maintenance of the small industrial boiler plant. It will appeal to operators who are studying the subject and at the same time it should be of practical value to any one engaged in boiler room engineering, assisting in correcting faults, tracing troubles, effecting economies and other problems which arise in the daily operation of the plant.

The book comprises ten concisely written chapters covering such topics as fuel, factors, heat-recovery auxiliaries, heat economies, boiler feedwater treatment, operation and maintenance topics, and boiler-plant testing.

2—Metallurgy
(Revised Edition)

By Carl G. Johnson

262 pages $5^3/_4 \times 8^1/_2$ Price $2.50

The purpose of this book is to provide the average man with practical information concerning the manufacture and behavior of metals and their alloys. For this reason the physical rather than the chemical aspects of metallurgy are stressed, though the chemistry of metallurgy is also adequately dealt with.

The information given covers such subjects as: the properties of metals and tests to determine their uses; producing iron and steel; important nonferrous alloys; copper and its alloys; heat treatments for steel; surface treatments; alloy on special steels; classification of steels; and powder metallurgy.

3—Power Plant Engineering and Design

By Frederick T. Morse

703 pages $6^1/_4 \times 9^1/_4$ Price $6.50

The second edition of Frederick T. Morse's "Power Plant Engineering and Design" holds to the original objective of presenting in one volume a complete study of electrical generating stations, including public service, industrial and institutional plants. The author has covered the mechanical and electrical aspects of power plant design and construction effectively and with due emphasis upon the economic factors involved. Approximately one-half of the text has been rewritten and many of the illustrations revised to include many refinements of design that have been introduced during the last ten years.

The work comprises fifteen chapters; the first four include a General Introduction, The Variable Load Problem, Power Plant Economics, and The Power Plant Building. Chapters five to seven deal with Diesel Engine Power and the Hydro-Electric Plant. Chapters eight to twelve concern Vapor Cycles and Their Heat Balances, Steam Boilers, Prime Movers, and Condensers, The Gas Loop, The Feedwater Loop, and The Piping System. The last three chapters concern Electric System Equipment and Layout, and also Metering Equipment.

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Post-War Fuel Supplies

The post-war United States eventually may be forced to rely on bituminous coal and oil shale deposits as additional sources of liquid fuel, Dr. A. C. Fieldner, chief of the Fuels and Explosives Service of the Bureau of Mines, stated in a talk on "Recent Developments in Fuels Supply and Demand," before the Western Society of Engineers, at Chicago, on April 22.

"Expected higher prices for fuel oil will tend to discourage new installations using this fuel," said Dr. Fieldner. "The greatest concern for the future supply of oil is the continuing decline during the past four years in the discovery of new fields. This calls for a marked increase in exploration to keep current withdrawals from reaching the point where total recovery is diminished."

He referred to Secretary Ickes' suggestion for the drilling of 4500 wildcat wells during 1943, as compared with 3045 wells drilled in 1942, and observed that if this enlarged exploration program is unsuccessful in restoring our former rate of finding new reserves of oil, the present trend of substituting coal for the industrial and domestic use of fuel oil may continue, and ultimately supplementary supplies of liquid fuel from oil shale, coal and vegetable products may be required. Continuing, he said:

"It is evident that the post-war trend probably will be in the direction of greater conservation of our national petroleum resources and in their more effective utilization. War-time progress in the production of high-octane aviation gasoline may lead to its use in improved types of high-compression internal combustion engines designed to obtain more mileage per gallon.

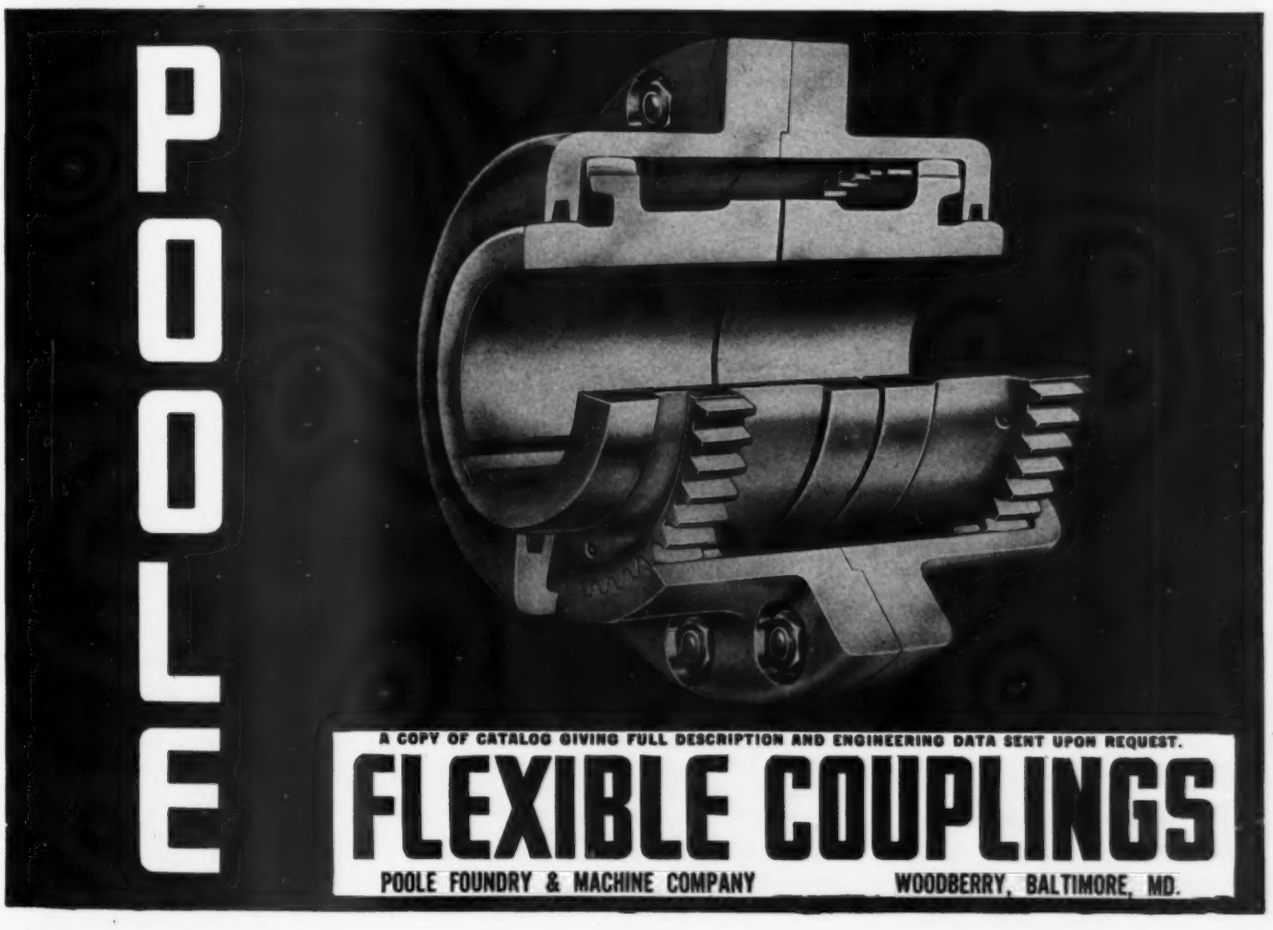
"If prices of motor fuel rise because of decreasing supplies, more attention may be given to secondary recovery from depleted fields and to the application of more expensive refining processes, such as pressure-hydrogenation of low-grade crudes. It is probable, also, that the Fischer-Tropsch process will be applied to the conversion of natural gas to gasoline. Large reserves of natural gas are available for such conversion in parts of the United States remote from our present centers of population and industrial activity.

"If these and other technical developments, together with the conceivable importation of oil from foreign sources, fail to meet the demand, prices may advance to the point where the production of liquid fuel from oil shale, coal, lignite and renewable vegetable sources will be economically feasible.

"Both the Bergius and the Fischer-Tropsch processes are in commercial use in Germany where more than half of the supply of gasoline is thought to be made from bituminous and brown coal. Costs by these methods are estimated to be three to four times that of producing gasoline from petroleum in the United States."

In reviewing fuel resources of the nation, Dr. Fieldner said that estimates of the total national reserves of petroleum cannot be made, but that figures must be based on proved reserves. The Committee on Petroleum Reserves of the American Petroleum Institute estimated the proved petroleum reserve to be 21.2 billion barrels on January 1, 1942, and 20.7 billion barrels on January 1, 1943. Reserves during the last five years have been kept up by extensions and revisions of estimates of reserves in old fields rather than the discovery of new fields. Regardless of whether we are on the threshold of a permanent decline of petroleum production or whether new discoveries will postpone this period for several decades, it is evident that our reserves of gas and petroleum are small compared to reserves of coal.

He said the deposits of oil shale, largely in the Rocky Mountain states, are estimated to contain a potential supply of 92 billion barrels of crude oil—sufficient to maintain the 1941 annual rate of oil production for 65 years. While the ultimate reserves of natural gas cannot be estimated, the estimated proved reserve as of January 1, 1942, was 85 trillion cubic feet. At the 1941 rate of 2.77 trillion cubic feet of production per year, this amount would last 30 years. Also, new sources may be discovered and the life of the fields, no doubt, will be extended greatly as growing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social control will prohibit waste and low-grade use of this ideal fuel.

Dr. Fieldner said that the original reserves of coal and lignite were estimated to have been 3.2 trillion tons, and that not more than two per cent of the original supply of bituminous coal and about 30 per cent of the anthracite have been exhausted. At the 1941 rate of energy consumption, assuming that coal will carry the load if and when oil, gas and oil shale are exhausted, and allowing 30 per cent for mining losses, coal would last 1500 to 2000 years. He asserted, however, that there certainly will be an increase in energy demand; and an increase at the rate of increase prevailing during the 1920's would cut the period to some 500 years. Thus a shortage of supply would be felt in the Appalachian field in a hundred years.

Decrease in Utility Budgets

The Federal Power Commission reports that the electrical utility industry contemplates construction expenditures during 1943 aggregating 539 million dollars of which 341 million is allocated to generating capacity. This total budget is some 216 million dollars under the actual construction expenditures during 1942, more than a third of the anticipated decrease being in generating capacity. Of the total 539 million dollars, about 52 per cent has been scheduled by privately owned utilities and 48 per cent by those publicly owned; and of the 341 million dollars budgeted for generating capacity, 139 million will represent steam, 200 million hydro and 2 million internal combustion engines. The actual expenditure for steam capacity in 1942 was 210 million dollars.

With 148,600 kw of new generating capacity placed in service during March of this year, the output was 18.8 per cent over that of the same month last year and the peak demand was up 13.7 per cent.

The latest available figures on revenues from sales to ultimate consumers by privately owned electric utilities are those for January 1943 which showed a 3.3 increase over January 1942. Despite this, the net operating revenue decreased 3.5 per cent because of increased operating expenses, depreciation and taxes.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request

Chain Drives

A general catalog of standard equipment (No. 850) is announced by Link-Belt Company. This is a 180-page book particularly designed for the man who orders spare parts. Dimensions, weights, list prices and other pertinent data are given on chains, sprockets, silent and roller chain drives, bearings, baseplates, take-ups, shafting, couplings, collars, clutches, pulleys, gears, buckets, conveyor idlers, screw conveyor, car spotters, speed reducers, etc.

Deaerators

Cochrane Corporation has issued a 36-page bulletin (No. 3005) describing its line of tray-type deaerators, atomizing deaerators, deaerating hot water generators and cold water deaerators. Sections are devoted to flow diagrams, corrosion control, pH control, metering deaerating equipment with V-Notch recorder and electrical systems for recording flow at a distance. Illustrations include line diagrams, cross-sections in halftone and installation pictures.

Dust Collectors

Thermix Engineering Company, in the March issue of *Thermix Topix*, features its line of tubular dust collectors made of non-priority ceramic fireclay. Two drawings illustrate the principle of operation and a typical design assembly. Also described in this 4-page bulletin is the curtain type Heacon Damper.

Compressors and Vacuum Pumps

Ro-Flo compressors and pumps of the sliding vane type are illustrated and described in a new 20-page bulletin (B-6211) just released by the Allis-Chalmers Manufacturing Company. Motors may be directly connected to Ro-Flo units which operate at speeds of 1200 or 1800 rpm. A complete engineering description is supplemented by installation diagrams; pressure, temperatures and volume curves; photographs and sectional views.

Pumps

Economy Pumps, Inc. has issued an 8-page catalog (D2-1042) featuring its new Type SCV pump. This unit, which is characterized by the vertical mounting of the motor, is available in various sizes for capacities ranging from 10 to 500 gallons per minute. Illustrations include sectional and assembly views. Dimension and selection tables are also given.

Reconditioning Worn Shafts and Rods

Four different methods of renewing worn metal parts such as pump shafts and rods are described in a new 8-page bulletin, "New Parts from Old," published by the International Nickel Company, Inc. Using a worn pump shaft as a practical example, the booklet explains and illustrates the step-by-step procedure for reconditioning the shaft: (1) by machining and refinishing the worn section; (2) by building up and refinishing the section by welding; (3) by metal spraying; and (4) by heavy and hard electrodeposition.

The Romance of Piping

A fascinating and attractively presented history of piping is featured in the current spring issue of Tube Turns' house magazine *Sparks*. This is a study worthy of an archeologist's thesis which tells of a copper pipe installation at the Pyramids 5000 years ago, Solomon's Acqueduct, stone and lead developments by the Carthagenians, Greeks and Romans, cast-iron piping's appearance in the fountains of Versailles in 1664, the Gas Light Era, down to the significant piping improvements of recent years. Authentic historical drawings illustrate the text of the story which is condensed to twenty minutes' intensely interesting reading.

Stoker Operation and Maintenance

Combustion Engineering Company has published a 20-page bulletin entitled "Fundamentals of Stoker Operation and Maintenance." This colorful booklet presents a series of separate advertisements designed to aid the War Effort in telling owner and operator—"How to Make Your Stoker Last Longer"—by setting forth fundamental facts concerning operation, lubrication, inspection and maintenance of stokers of all types. This includes: Single-Retort and Multiple Retort Stokers, Chain Grate and Traveling Grate Stokers, and Spreader Stokers. Examples are also given of typical oil-fired boiler installations converted to coal-firing. The final pages of the bulletin are devoted to a technical paper entitled "Some Ways to Avoid High Stoker Maintenance." This discusses maintenance with respect to all types of stokers and cites numerous difficulties encountered and the measures taken to remedy them.

Worm Gears

De Laval Steam Turbine Company has issued a 4-page leaflet (E-1219) describing its line of worm gears for 3-in. and $3^1/_2$-in. center distance. These gears are supplied for either top or bottom drive and in ratios from $3^5/_8$ to 1 up to 60 to 1 and are intended for the operation of low-power machinery. The leaflet is illustrated and gives standard dimensions and horsepower ratings.